AMF ON-POWER REFUELING SYSTEM FOR A CANDU-TYPE REACTOR

ADAPTER VALVE DEVELOPMENT MASTER REPORT

FEBRUARY 1963

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AMF ATOMICS

GREENWICH, CONNECTICUT
CONTRACT AT (38-1)-233
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ADAPTER VALVE DEVELOPMENT REPORT
AMF ON-POWER REFUELING SYSTEM

Facsimile Price \$ 13.00

Microfilm Price \$ 5.84

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

February 1963

AMF ATOMICS

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ADAPTER VALVE DEVELOPMENT REPORT
TO THE
UNITED STATES ATOMIC ENERGY COMMISSION
SAVANNAH RIVER OPERATIONS OFFICE
FOR THE
AMF ON-POWER REFUELING MACHINE
FOR A CANDU-TYPE REACTOR

February 1963

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Work Performed For
The United States Atomic Energy Commission
Contract No. AT(38-1)-233

AMF ATOMICS

A Division of
American Machine & Foundry Company
140 Greenwich Avenue
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Artist's Concept of Adapter Valve

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ADAPTER VALVE DEVELOPMENT REPORT
TO THE
UNITED STATES ATOMIC ENERGY COMMISSION
SAVANNAH RIVER OPERATIONS OFFICE
FOR THE
AMF ON-POWER REFUELING SYSTEM
FOR A
CANDU-TYPE REACTOR

INTRODUCTION

This document reports a portion of the work performed by AMF Atomics, a division of American Machine & Foundry Company's Government Products Group, under contract number AT(38-1)-233, dated 17 January 1961 with the USAEC, Savannah River Operations Office, for the development activity specified herein.

The objective of the over-all activity was to develop, design, fabricate and test a prototype, alternate on-power refueling head and components for operation with a CANDU-type, heavy-water moderated, power reactor. On-power refueling permits the loading and unloading of natural-uranium fuel in rod-bundle form while the reactor is operating at full power.

This work is being performed under a cooperative program between the USAEC and Atomic Energy of Canada, Limited. The program covers the development of heavy-water moderated, power reactors, and is administered by the Savannah River Operations office of the USAEC.

This report is concerned primarily with the reference adapter valve which is an integral part of the refueling machine head. When the adapter valve is installed on the reactor process-tube end-fitting, and the ball valve is closed, the reactor coolant is contained permitting connection of the three handling tubes for reactor component or fuel handling. The parallel

development of an alternate adapter valve was carried to the point at which sufficient confidence in the reference concept caused deferment of further alternate concept development. A discussion of this alternate appears in Appendix A.

The open valve serves as a port through which new or used fuel bundles, end-seals, and the shield-plug are either removed or installed. A gimbal joint is provided to compensate for the anticipated misalignment occurring between the reactor process tube and the machine head. All necessary controls, instrumentation, and actuation devices for control-center-type remote operation are mounted adjacent to the valve. The adapter valve is designed to operate at reactor upstream and downstream conditions. External heating elements and insulation are provided to optimize isothermal matching of the valve to the reactor end-fitting.

The intent of this report is to document AMF reference and alternate adapter valve design, and reference adapter valve manufacture and test as achieved at the Steamboat Road Laboratory, Greenwich, Connecticut. Concept development of these valves is covered in the Task I Completion Report AMF-388-TR-2. The test discussion in this report is limited to component testing. Test operation of the reference adapter valve as part of the refueling head system will be provided in a separate report at a later date.

Figure I. Adapter Valve Cross-Sectional View

KEY TO FIGURE I

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FOREWORD

ADAPTER VALVE DESIGN

The design objective of Task III, Subtask 2 of the AMF ON-Power Refueling Machine Work Program was the preparation of detailed drawings from approved design concept layouts of an adapter valve. The layouts were based on the Task I reference concept and those Task II test results applicable to the adapter valve. Task I Completion Report, AMF-388-TR-2, dated July 1962, describes in detail, on pages 114 through 122, the basic adapter valve concept. The Component Feasibility Test Report, AMF-388-TR-1, dated February 1962, on pages 2-1 through 2-8 and 4-1 through 4-19 details those test results which were incorporated in the adapter valve design, (see figure I).

OVER-ALL SIZE

Task I system studies indicated that the over-all length and cross-sectional area of the adapter valve was a critical consideration in determining the handling tube lengths and the tube support spacing on the cradle assembly. Spacing was severely restricted as limited clearance existed when considering the floor level, the proposed machine carriage, and the ceiling on which insulated feeder pipes were located.

The size of the adapter valve was also a critical factor as the weight would cause reactor end-fitting deflection and impose a cantilevered load on the end-fitting bearing.

During design and detailing, every effort was directed toward maintaining a rigid control of the over-all configuration, wall thicknesses and component detail to assure a most effective application of material and area subjected to stress.

SEAL SELECTION

Task I studies and Task II testing indicated that metallic seals would be the most effective sealing members for the adapter valve assembly.

Accordingly a commercial-type metallic seal, modified to match the reactor end-fitting, was used as the end-fitting seal ring (25, figure I). This same seal was also used as the body seal between the two removable portions of the assembly. This approach provided accessibility to the most critical parts of the unit, the ball and ball seal.

The choice of stem seals (6) was another critical decision. A search of commercially-available seals revealed that few devices would provide the necessary reliability and ability to function within the limited maintenance to which the assembly was subjected. Several seal manufactures suggested seal materials for which limited temperature-and-radiation history was available. Other seals required more area than that available in the over-all valve package. After considerable liaison, a manufacturer was found who was willing to develop and test an all-metallic seal to meet our needs. This seal was incorporated in the design.

Task II feasibility testing revealed the sealing potential of both silver-graphite spherical seal material and a special composite stainless steel-and-silver material developed by the Armour Research Foundation. The evaluation of both materials, and the commercial inavailability of the composite material led to the selection of a silver-graphite seal for the reference design.

ADAPTER VALVE MANUFACTURE

A prerequisite to the fabrication of the adapter valve assembly from the drawings prepared in Task III was the timely purchase of the required materials, commercial components, and hardware for one assembly within the estimated price. The adapter valve assembly required many components

which were both one-of-a-kind and fabricated of temperature-resistant materials. As a result, procurement of the housing raw material, bellows assemblies, stem seals, and other commercials was complex and time consuming. Many times the specified design materials were difficult to obtain; consequently design alternates had to be developed to alleviate the problem areas.

WELDING

The selected design specified the joining of portions of the valve housing the gimbal bellows by stainless-steel welding (see figures II and III). The housing was fabricated of 347-stainless steel to preclude high temperature stress relieving and heat treatment prior to final machining. The use of this steel obviated the possibility of distortion and the need of considerable final machining of heavy-walled components. The final welding of the gimbal assembly to the housing was carefully planned to reduce the risk of rewelding or machining. However, the radiographs indicated inclusions and voids in the last several weld passes which required machining out and rewelding. A review of the weld procedure revealed that the geometry of the gimbal flange limited the weldor accessibility to the flange neck making proper fusion difficult.

SPECIAL MACHINING

A number of special finishes were required to meet the specified sealing requirements of the mating components. The housing hubs (11, figure I) used in conjunction with commercial clamps, required a spherical-roll-burnish finish to reduce the possibility of galling the mating surfaces and to provide maximum sealing effectiveness. These hubs also provide a mating surface for a commercial seal ring (14).

After a detailed study of the problems involved in developing satisfactory machining techniques and tooling costs, it was decided to subcontract the machining to the vendor who developed the finishing process.

Figure II. Adapter Valve Housing - Before Welding

Figure II. Adapter Valve Housing Weldment

VALVE ASSEMBLY

A detailed assembly procedure was established to facilitate the intricate assembly of the valve. This procedure established the close clearances required for ball and ball-seal function through the complete range of operation. The procedure was based on an analysis of the manufacturing tolerances and required component clearances. The depth of ball-to-ball-seal engagement under various wedge positions determined the final thickness of an internal thrust washer. (19)

REFERENCE ADAPTER VALVE

PURPOSE

This test report is intended to document the results of the Reference Adapter Valve Test Program. The valve was tested as outlined in the Test Specification, Revision I, dated March 1962. The valve tested conformed to the design shown on AMF drawing 89-58-E-5000, and Specification 89-58-1005. Refinements, experienced through fabrication, and modifications necessitated through testing, have been incorporated into the design and the test program as applicable.

SCOPE

The scope of the adapter valve test program was based on obtaining the maximum amount of useful data within the limits of the over-all project objectives. As a consequence, testing was divided into two basic categories:

- a. Generation of base-line data.
- b. Establishment of secondary data.

BASE-LINE DATA

Base-line data, as defined, included all necessary test information required to permit an effective engineering evaluation of adapter-valve critical-component performance. To attain this goal data for the valve assembly as well as its accessories were collected under consecutive conditions of room environment, room temperature-and-maximum operating pressure, and maximum operating pressure-and-temperature. Base-line data included functional checks, visual inspections, adjustments, calibrations, and measured data, viz., strain, leakage, torque and thermal gradients. An order of priority for base-line data assimilation, prior to cyclic

testing, was established to demonstrate technical feasibility as soon as possible.

SECONDARY DATA

After the establishment of base-line feasibility data, secondary data was compiled to determine the operability of the unit under reactor environmental conditions of pressure and temperature. Since the system operating philosophy is that of maintaining the valve at reactor coolant conditions while in the refueling vault, thermal cycling simulated only the varying upstream and downstream end-fitting temperatures (from 480° to 568°F).

SUMMARY

The adapter valve was tested under the following conditions:

- a. Room-temperature, maximum operating-pressure.
- b. Room-pressure, maximum operating-temperature.
- c. Maximum operating-temperature, operating-pressure.

A summary of the test results for each adapter valve component, under the applicable test environment, follows:

FORWARD CLAMP AND SEAL RING

It was determined that a tightening torque of 50 foot-pounds sealed the forward clamp (16, figure 1) against visible leakage at 1500 psig pressure and both ambient and operating temperatures. Torque was manually applied to the operating shaft of the forward clamp.

The forward clamp was mechanically cycled 18 times, after which inspection revealed no evidence of wear, seal-ring (15) distortion, or change in shaft torque requirements.

1. CO ₂ MANIFOLD ASSY	10. INSULATION HOUSING
2. WORM WHEEL	11. WEDGE
3. GENEVA MECHANISM	12. HEATER ELEMENTS
4. PNEUMATIC MOTOR	13. GIMBAL BELLOWS
5. BALL SHAFT	14. FUEL-STOP ASSY
6. WEDGE SHAFT	15. SEAL RING
7. BALL	16. FORWARD CLAMP
8. BALL-SEAL RING	17. HOMING SENSOR ASSY
9. BODY CLAMP	

Figure 1. Adapter Valve — Cutaway View

BALL SEAL

The ball seal (7, 8) was tested at 1500 psig pressure at both ambient and maximum operating temperatures. Leakage past the ball seal was determined to be well within the maximum acceptable leak rate of 300 cc per hour. Testing indicated the actual leak rate to be 75 cc per hour at ambient temperature and 1500 psig pressure, and 125 cc per hour at maximum operating temperature and 1500 psig pressure. The tightening torque applied directly to the wedge shaft (6) to obtain these leak rates was 30 foot-pounds.

Based on test performance, it was found that the leakage at all points of the adapter valve was substantially less than the total permissible leakage of 700 cc per hour.

BODY CLAMP

The 6-inch fixed body clamp (9) was tested at 1500 psig pressure at both ambient and maximum operating temperatures. The tightening torque was set at 200 foot-pounds. Throughout the test program no leakage was observed through this clamp, despite its having been disassembled and assembled thirty-four times. This data lends further credence to the test data collected on the remotely operated forward clamp and seal ring.

HEATER ELEMENTS

The heater element tests indicated that the external body heater (12) principle is feasible for maintaining the external valve body temperature from 500° to 600°F with a temperature difference no greater than 50°F between the internal and external valve surfaces. During testing of the heater elements, the temperature of the forward clamp area of the valve was approximately 260°F lower than the rest of the valve body. Areas properly incased in the heater elements were maintained at the specified temperature.

STEM SEALS

The ball- and wedge-stem seals functioned satisfactorily under cold-water, high-pressure conditions, however, during the high-temperature portion of the program, both seals exhibited very short life cycles. The failure was attributed to fatigue of the seal ring possibly precipitated by the application of an excessive side load. Subsequent testing by the manufacturer indicated that another metal combination might better suit the valve operating conditions.

During continued testing of the adapter valve, the reworked seals were exposed to both ambient- and maximum operating-temperature conditions at 1500 psig pressure. The seals again performed satisfactorily until failure which occurred after an additional 46 pressure cycles and 252 dynamic cycles. This failure consisted of circumferential cracking of the dynamic gasket on both seals.

INSULATION

The adapter valve insulation (10) was utilized during the maximum operating-temperature, operating-pressure tests. The insulation consisted of aluminum, sheet-metal forms packed with magnesia insulating material. The insulation was effective as the operating temperature of the valve was maintained with a reasonable use of the heating elements.

FUEL STOP

Fuel-stop tests indicated that a pneumatic pressure of 140 psig was required to actuate the fuel-stop (14) with the adapter valve at ambient temperature with an internal pressure of 1500 psig. Testing of the fuel stop has not been completed at this time. This test shall be completed during testing of the machine head when the adapter valve is operated as one of the

machine head components, since fuel-stop operation is dependent upon a number of tube assembly components.

VALVE HOUSING

Of prime consideration in the valve housing design were the capability to withstand the extreme stresses induced by the clamps and the ability to operate at high pressure and temperatures. During testing, analysis showed that the major contributing stress factor was the initial tightening torque applied to the 6-inch-pipe-clamp rings. As testing progressed, however, it was determined that the initial vendor-recommended torque was higher than necessary by an approximate factor of 3. A reduction in torque requirements, in effect, simplified the over-all stress problem. Thermal and mechanical cycling have indicated that the housing configuration is adequate for the specified temperature and pressure conditions.

GIMBAL JOINT AND HOMING SENSORS

No tests were conducted on the gimbal joint (13) or the homing sensors (17). These items will be tested during system testing of the machine head when the adapter valve is operated as a component of the machine head assembly.

CONCLUSION

Adapter valve testing has proven conclusively that the adapter valve is capable of serving its prime design function, that of containing the moderating fluid, water, under reactor conditions. This not only indicates its soundness as a design concept, but also provides a firm foundation for future ball-valve applications. Specific conclusions are as follows:

LEAKAGE TESTING of the adapter-valve-ball seal has indicated that the referenced ball seal performs within the maximum acceptable leakage rate of 300 cc per hour. The actual leak rates were found to average 75 cc per hour under environmental conditions of ambient-temperature and 1500 psig, and 125 cc per hour under environmental conditions of operating-temperature and 1500 psig. The ball-graphite-seal principle was found feasible for maintaining a demineralized water leakage rate less than 300 cc per hour, with the water pressure varying from zero to 1500 psig and the water temperature varying from 70° to 580°F. These leakage rates were obtained with a tightening torque of 30 foot-pounds applied directly to the top of the wedge shaft.

Without a wedge force applied to the ball, the ball-seal was still capable of maintaining a leakage rate less than the maximum acceptable rate of 300 cc per hour, provided the internal adapter valve pressure was greater than 250 psig.

The principle of a specially-constructed, three-segment clamp used in conjunction with a commercial seal ring to form the adapter-valve-forward clamp appeared feasible. A relatively low tightening torque of 50 foot-pounds was used to set this clamp, and no leakage was observed from the clamp throughout the entire test program. The tests completed were not sufficiently extensive to predict or determine component service life.

The HEATER ELEMENT TESTS indicated that the external body heater principle was feasible for maintaining a valve body temperature at a nominal 560°F with a temperature difference no greater than 50°F between the internal and external surfaces of the valve.

The use of METALLIC SEALS on the ball- and wedge-stems showed that the use of such seals is feasible. The seals did not score either shaft and the seal friction was within predictable and practical limits. The metallic seals performed successfully within the leakage specifications; however, the seal life was much less than that expected and efforts are necessary to improve the seal life to a more practical range.

The metallic seal piston rings, as used on the fuel-stop piston, did not provide a seal sufficient for proper operation of the fuel-stop. After the metallic seal rings were replaced with organic seal rings the fuel-stop could be operated satisfactorily.

The 410-stainless-steel-commercial-seal rings incorporated in the adapter valve design appear to have a longer life than the same seal rings fabricated from 316-stainless steel.

The ACTUATING-TORQUE VALUES required for the operation of the forward clamp and the ball-actuating mechanism were less than those expected. The pneumatic motors incorporated in the development design developed forces far in excess of the actual requirements, and did not afford sufficiently sensitive motor control for safe operation of the ball-actuating mechanism. Sub-components of the ball-actuating mechanism were damaged due to the excess dynamic force developed by the pneumatic motors.

The PNEUMATIC PRESSURE required to open the fuel-stop when the adapter valve was pressureized to 1500 psig was greater than expected. The expected operating pressure was 125 psig; the test results indicate pressure of 140 psig is required.

The STRESS capabilities of the valve housing were found acceptable during the test program. The greatest stress condition to which the valve housing was subjected occurred at the 6-inch pipe clamp located at the machine end of the valve. An evaluation of the load mechanism resulted in a recommendation to reduce the tightening torque applied to this clamp from 350 foot-pounds to 200 foot-pounds. This reduction in the clamp tightening torque had no effect on the sealing characteristics of the clamp. The unit was rated at 2600 psi at the reactor operating temperature. Tests conducted at ambient temperature and operating pressure, and instrumented with strain gages, indicated that the valve housing stress induced by the internal-hydraulic pressure was of minor proportions.

RECOMMENDATIONS

As a result of adapter valve testing, the following modifications to the development design, which will improve valve operability, are recommended:

PNEUMATIC REQUIREMENTS

Replace the present pneumatic actuator with a smaller capacity motor, rated at 30 foot-pounds output torque at 300 RPM and fitting the existing ball-actuating-mounting bracket. Tests have indicated that the pneumatic actuator initially mounted on the ball-actuating mechanism and its related gear mechanism and jacking screw generate excessive torques. Needle valves suitable for this system are not sensitive enough to adjust for the proper torque output.

WEDGE-TO-WEDGE SHAFT ATTACHMENT

Several failures occurred at the attachment point of the wedge shaft during testing. To eliminate this condition, alter the presently referenced wedge-shaft design to one which will withstand all anticipated loads at maximum operating conditions. Revise the width of the wedge and its connection to the wedge shaft to increase the cross-sectional area subject to shear, and to remove all stress concentrations. An accompanying reduction in clamp and backing ring thickness will accommodate this enlargement without altering the over-all size of the assembly.

CLAMP-RING MOVEMENT

To eliminate any vertical movement of the clamp ring and thus minimize any scoring of the ball by this action, the diameter of the clamp ring should be increased to a sliding fit with the adapter-valve-housing bore.

Alter the clamp-ring material to provide hard-chrome plate on the side contacting the wedge to avoid scoring the ball sealing surface.

BALL FINISH

To minimize scoring of the ball, the surfaces of the ball should either be hard-chrome plated or fabricated of a material harder than the contacting members.

HEATER REQUIREMENTS

Test data indicates that an additional heater element should be located at the forward-clamp area of the valve; or, the present heater elements should be re-arranged to provide more heat to this valve area. The heater configuration may be improved to provide more even body temperatures.

BALL-ACTUATING MECHANISM

A positive stop should be designed and installed on the ball-actuating mechanism to eliminate the possibility of the wedge striking the top of the valve-housing bore during the wedge-retraction operation.

DIAMETRAL CLEARANCE

Due to seizures between the ball and ball housing experienced during high-temperature testing of the adapter valve, the clearances in this area must be increased. A minimum of 0.035-inch increase in the diameter of the ball housing is recommended.

AXIAL MOVEMENT

To ensure that the ball and the ball-seat key move axially as a unit upon application of the wedge force, the ball should be pinned to the ball-seat key. If the ball and ball-seat key do not move as one, improper ball seating in the graphite seat can occur and cause gross water leakage.

STEM-SEAL MATERIAL

Change the material of the stem seals to one that is less subject to fatigue failure but retains the same sealing characteristics.

To provide greater ductility, stainless steel 440A is recommended.

TEST PROCEDURE

ADAPTER VALVE -GENERAL DESCRIPTION

The adapter valve serves as a means of retaining the reactor coolant during refueling operations at the reactor. The valve is normally carried on the end-seal tube, and may be operated with any of the three refueling-machine handling tubes. The valve may be clamped and sealed on any of the handling-tube shutoff valves. The valve consists of a flexible joint to accommodate machine-to-end-fitting misalignment, a pneumatically-actuated ball-valve, a remotely-actuated fuel-stop, and a pneumatically-actuated clamp-and-seal for connection to the reactor process-tube end-fitting. Homing sensors, located on the reactor-end of the valve, provide final X- and Y-machine control to locate this assembly on the process-tube with which it is to function. The valve provides a passage for the reactor and machine components and the fuel bundles which either are removed or inserted into their respective containment areas during a refueling cycle.

The major components of the adapter valve are:

- a. The VALVE BALL (1, figure 2) and GRAPHITE SEAT (2) which serve to shut off the reactor moderating fluid between the process tube and refueling machine. The ball is opened and closed through a 90-degree rotation by means of a pneumatic motor (39, 40, and 41), driving through a worm (15) and worm-wheel (6) gear-reduction, and a modified-geneva mechanism (72) and ball stem.
- b. The BALL-VALVE-ACTUATION MECHANISM serves to position the valve ball either in a fully-opened or a fully-closed position. This mechanism is externally mounted with the valve stem (13) penetrating the housing through a rotary dynamic seal. A pneumatic motor rotates the gear-reduction mechanism attached to the valve stem.
- c. The BALL-CLAMP RING (73) and WEDGE ACTUATION MECHANISM serve to load the ball-seal combination to enhance their sealing characteristics, and to release the load on the ball-seal combination just prior to ball rotation. The former opens while the latter closes the ball valve improving the over-all wear characteristics and, as a result, the service life of the ball-seal combination. A pneumatic motor, driving through a worm-and-worm wheel gear reduction stem, and rotary seal actuates a wedge (43) against the clamp ring which exerts a uniform pressure on the ball-seal (1,2) combination to effect a seal. This motion is synchronized by means of a modified-geneva mechanism (72) to preclude ball rotation with high unit loads on the ball-seal combination.
- d. The FORWARD CLAMP-ACTUATING MECHANISM serves to remotely actuate the three segment clamp to either connect the adapter valve assembly to, or release it from, the pressure tube. A pneumatic motor driving through a gear reduction actuates a compound screw (67) which pivots the clamp segments together or apart.
- e. The FUEL-STOP (4) serves to separate and control the number of fuel bundles and reactor plugs passing through the adapter valve. The

Figure 2. Adapter Valve — Disassembled (Sheet 1 of 5)

<u>Item No.</u>	<u>Part Number</u>	<u>Nomenclature</u>
1	89-58-5011-1	Ball
2	89-58-5014-5	Ball Seal
3	89-58-5014-6	Ball-Seal Sleeve
4	89-58-5013-1	Fuel-Stop Head
5	89-58-5013-4	Fuel-Stop Fingers
6	89-58-5022-2	Worm Wheel
7	89-58-5010-5	Wedge-Operating Worm Wheel
8	89-58-5011-5	Wedge-Operating Shaft
9	89-58-5012-6	Cap
10	89-58-5011-3	Ball-Housing Cap
11	89-58-5013-5	Studs
12	89-58-5010-8	Geneva Lock
13	89-58-5011-6	Ball Shaft
14	89-58-5021-5	Worm Key
15	89-58-5010-6	Driving Worm
16	89-58-5021-7	Seal-Retaining Ring
17	89-58-5012-4	Clevis
18	89-58-5018-8	Spacer
19	89-58-5004-23	Double-Seal Piston Rings
20	89-58-5017-5	Clamp Guide
21	89-58-5015-6	Clamp Guide
22	89-58-5018-7	Spacer
23	89-58-5021-6	Worm Spacer
24	89-58-5014-7	Clamp Ring Key
25	89-58-5018-9	Stop Mounting Bracket
26	89-58-5022-6	Operating Screw Gear
27	89-58-5022-5	Intermediate Gear
28	89-58-5010-1	Upper Spring Washer
29	89-58-5021-7	Seal Retaining Ring
30	89-58-5013-3	Switch Bracket
31	89-58-5022-4	Stud
32	89-58-5010-4	Shaft-Cap
33	89-58-5017-3	Bearing Cap
34	89-58-5010-3	Lower Spring Washer
35	89-58-5010-2	Shaft Spring
36	89-58-5012-7	Gland
37	89-58-5022-3	Stud
38a	89-58-5022-8	Switch Mounting Bracket
38b	89-58-5017-2	Stop Mounting Bracket
39	89-58-5023-2	Clamp Motor
40	89-58-5023-1	Ball Actuator Motor
41	89-58-5023-2	Clamp Motor
42	89-58-5021-1	Air Motor Bracket
43	89-58-5014-2	Wedge

Figure 2. Adapter Valve — Disassembled (Sheet 2 of 5)

<u>Item No.</u>	<u>Part Number</u>	<u>Nomenclature</u>
44	89-58-5021-2	Switch Mounting Bracket
45	89-58-5025-6	Bracket
46	89-58-5004-23	Double-Seal Piston Rings
47	89-58-5012-1	Head Subassembly
48	89-58-5018-4, -5	Clevis Nuts
49	89-58-5011-2	Wedge-Housing Cap
50	89-58-5010-7	Geneva Drive Pin
51		0.062-inch Bar-X Seal
52	89-58-5021-3	Geneva Stop
53	89-58-5025-1	Mounting Column
54		Unimax Leaf Actuators
55	89-58-5014-8	Ball Seat
56	89-58-5011-7	Ball-Shaft Washer
57	89-58-5022-1	Spacer
58	89-58-5014-3	Wedge-Elevating Washer
59		Unimax Switches
60	89-58-5022-7	Operating-Screw Key
61	89-58-5010-9	Drive-Worm Key
62	89-58-5011-8	Ball-Shaft Key
63	89-58-5024-1 thru 7	Bushing
64	50007	Clamp
65		Clamp Bolt
66	50714	Seal Ring
67	89-58-5018-6	Operating Screw
68	89-58-5025-3	Level Guide
69	89-58-5024-4	Flat Spring
70	89-58-5025-5	Spring Holder
71	89-58-5013-2	Head Gasket
72	89-58-5011-4	Geneva Wheel
73	89-58-5014-1	Wedge Backup Ring
74	89-58-5025-7	Bracket
75	89-58-5007	Adapter Valve Housing Weldment
76	89-58-5015-7	Clamping Hub
77	SS-410	Grayloc Rear Seal Ring

Figure 2. Adapter Valve — Disassembled (Sheet 3 of 5)

Figure 2. Adapter Valve — Disassembled (Sheet 4 of 5)

Figure 2. Adapter Valve — Disassembled (Sheet 5 of 5)

ice-tongs-like fuel-stop (5) is actuated through a linkage by a pneumatically-actuated piston (47). In the retracted position, the fuel-stop tongs are outside the adapter-valve diameter. When the fuel-stop is actuated, the tongs close decreasing the inner diameter and preventing passage of a fuel bundle. Each handling tube is provided with control instrumentation to assure proper remote actuation of the fuel-stop.

- f. The GIMBAL JOINT serves to provide a relatively flexible section in the adapter valve assembly to permit remote clamping of the adapter valve to the process tube with a small misalignment of the central axis. The gimbal joint is designed to accommodate a 1/2-degree skew relationship between the two clamped units. The gimbal joint, which is incorporated between the ball housing and the fuel stop, consists of a bellows section, with gimbal plates at either end, and thrust bolts. The thrust bolts consist of preloaded Belleville washer assemblies mounted between the gimbal plates to provide control in the vertical and horizontal planes.
- g. The HOMING SENSORS control the various cradle drive systems. These sensors are located at the leading edge of the adapter valve assembly and face the process tube. They make contact with, and generate information from, the process-tube OD for final refueling machine positioning and in clamping and sealing the process-tube end-fitting.
- h. The HEATER ELEMENTS serve to preheat and maintain the adapter valve body temperature during valve startup and operation. The heater elements consist of a series of tubular electrical, resistance-type units which are shaped to fit the contours of the valve body. Each section is wrapped to provide uniform housing temperature. The elements are located around the 6-inch rear clamp, the ball valve housing, and the gimbal joint areas of the adapter valve. The heater elements are thermostatically controlled and operate on 550 VAC.

- i. (See figures 3 and 4.) The adapter valve INSULATION serves to maintain the valve body temperature during operation and reduce the possibility of excessive thermal stresses. The insulation consists of aluminum sheet-metal forms which are shaped to the contour of the valve body and packed with magnesia insulating material. The forms are bolted together to form three sections; one is installed around the 6-inch rear clamp, the second is mounted around the ball valve housing, and the third is mounted around the gimbal joint. Each section encases the associated heater element and isolates low-temperature equipment from effects of heat.
- j. The STEM SEALS (16, 19, figure 2) are metallic seals and serve to seal the ball and wedge shafts at the point of shaft penetration through the adapter valve body. These seals contain both static and dynamic details. The dynamic seals contact the shafts while the static seals contact the valve housing. The stem seals are commercial proprietary items. Initial investigations were accomplished by the vendor.
- k. (See figure 5.) The CO₂ MANIFOLD AND VALVE ASSEMBLY serves to control and direct the flow of CO₂ required for the actuation of the full-stop, the forward clamp pneumatic motor, and the ball actuating mechanism pneumatic motor. The manifold consists of a directional valve, solenoid valves, pressure regulator, check valves, relief valve, and the necessary tubing and hose assemblies.

BASE-LINE DATA GENERATION

In a test program of this type, an order of priority and the planning of an orderly and systematic generation of test data is essential. The goal is a maximum amount of useful data within the limits of economy and time to establish the feasibility and operability of the test component. Base-line testing was performed to evaluate the ability of the adapter valve sub-components to function satisfactorily and reliably within the specification

Figure 3. Insulation Housing — Disassembled

Figure 4. Insulation Housing Installed

Figure 5. CO₂ Manifold and Dead Weight Testing Apparatus

requirements. The conditions under which the adapter valve was tested were:

- a. Demineralized water with a pH of 9.5 to 10.5 at room temperature and atmospheric pressure or normal room environment.
- b. Demineralized water with a pH of 9.5 to 10.5 at room temperature and internal pressures up to 1500 psig; or room temperature and operating pressure.
- c. Demineralized water with a pH of 9.5 to 10.5 at an internal and external temperature of approximately 585°F and 1500 psig pressure; or maximum operating temperature and operating pressure.
- d. The environmental test conditions external to the insulation were those of the normal room environment.
- e. Housing temperatures were increased at a rate not exceeding 20°F per minute, nor was a temperature difference greater than 50°F between the internal and external surfaces of the valve ever generated.
- f. Test pressures were increased from atmospheric pressure to 1250 psig in increments of 250 psig, and from 1250 to 1500 psig in increments of 50 psig.

STRAIN TESTING

Prior to the start of adapter valve testing, the valve was instrumented with high-temperature strain gages. The gages were mounted at various predetermined critical points on the external surface of the adapter valve in order to determine and monitor the degree of strain to which the valve body would be subjected to during testing. This data was translated into stress values for comparison with allowable stress limits of the assembly materials.

Test Equipment and Instrumentation

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
Strain Gage	Baldwin Lima-Hamilton	Receive and transmit strain.
a. FNH-50-12, Nichrome, 1/2 inch		
b. FNO-25-12, Nichrome, 1/4 inch		
c. FAH-50-12, Constatan, 1/2 inch		
Adhesive, EPY-400	Baldwin Lima-Hamilton	To secure gages to valve housing.
		To record impulses picked up by strain gages.

Test Setup

Each strain gage was attached to the adapter valve housing as shown in figure 6. The gages at locations 2 and 25 were type FNH-50-12. Those at location 4, 5, 14 and 16 were type FNO-25-12, while type FAH-50-12 was applied at locations 12 and 24. The gages and instrumentation were connected and internal valve pressures were obtained through the hot water circulating system.

Figure 6. Strain Gage Locations

Test Procedure

Strain testing of the valve housing proceeded in two preplanned series. The first phase was directed toward determining the valve housing strain induced by tightening the 6-inch pipe clamp hub bolts. The second series was accomplished with the assembled valve under the rated 350 foot-pounds torque and pressurized from zero to 1500 psig.

To determine VALVE BODY CLAMP STRAIN, the six-inch-pipe clamp hub ring was mounted on the valve housing and the clamp bolts tightened with 10 to 50 foot-pounds torque and also from 50 to 350 foot-pounds torque in increments of 50 foot-pounds. Strain was recorded at each increment at gage locations 2, 4 and 5. See data sheet 1 for results.

To determine VALVE BODY PRESSURE AND CLAMP STRAIN, and after reaching 350 foot-pounds tightening torque on the six-inch pipe clamp, strain readings were obtained from all gages with (1) zero pressure on each side of the ball, (2) with 1500 psig pressure on each side of the ball and (3) with 1500 psig pressure on the reactor side and zero pressure on the machine side. See data sheet 2 for results.

Test Discussion

The maximum strain obtained was calculated to be equivalent to 34,000 psi stress. This strain was recorded with the 6-inch pipe clamp hub tightened with a torque of 350 foot-pounds, the ball valve closed, and the internal pressure on the reactor side of the ball valve increased to 1500 psi with the pressure on the machine side of the ball valve remaining at zero psi. This strain was indicated by strain gage 4, which was located in an anticipated high stress area. The major portion of this strain (30,000 psi stress) resulted from the 350 foot-pound tightening torque applied to each bolt of the 6-inch pipe clamp hub. (See data sheet 2.)

The yield strength of 347-stainless steel (0.2 per cent offset) at 70°F is 39,500 psi and decreases to 32,000 psi at 500°F. Considering the 30,000 psi stress induced by the 350 foot-pound tightening torque applied to each bolt of the clamp at room temperature, it was essential that the clamp tightening torque be reduced to 200 foot-pounds. A torque of 200 foot-pounds applied to the pipe clamp resulted in a calculated stress of 20,000 psi as recorded by strain gage No. 4 (see data sheet 2).

Test Data

DATA SHEET

PAGE NO.	TORQUE ON GRAYLOC CLAMP ±T-lbs	PRESSURE (PSI)		STRAIN MICROIN/IN	STRESS (PSI)
		REACTOR SIDE	MACHINE SIDE		
2	350	0	0	102	2,920
4	350	0	0	1050	30,000
5	350	0	0	800	22,800
14	350	0	0	0	0
2	350	1500	1500	267	7,610
4	350	1500	1500	1137	32,400
5	350	1500	1500	952	27,200
14	350	1500	1500	401	11,400
2	350	1500	0	282	8,050
4	350	1500	0	1190	34,000
5	350	1500	0	712	20,400
14	350	1500	0	400	11,400
24	350	0	0	5	143
12	350	0	0	15	429
16	350	0	0	10	286
25	350	1500	0	65	1,860
24	350	1500	0	40	1,140
16	350	1500	0	510	14,600

TOTAL STRESS OBTAINED UNDER VARIOUS CONDITIONS.

DATA SHEET NO. 1

DATA SHEET NO. 2.

[illegible]

INITIAL STEM-SEAL TESTS

The stem seals specified in the adapter valve housing are of commercial design having limited field experience. Little data at the maximum operating temperatures and pressures were available and, as a result, settings were extrapolated from past experience to establish initial and final torque relationships meeting the specified leakage requirements.

Test Equipment and Instrumentation

No special test equipment or instrumentation was required for testing the stem seals. A torque wrench, spanner wrenches, and the valve housing were used in these tests.

Test Setup

The stem seals were installed in the adapter valve; one seal on the ball actuating shaft, and the other on the wedge actuating shaft. An adjusting nut provided the means of varying seal pressure on the shaft. This torque variation permitted stem rotatability. Each unit was set with a torque of 120 inch-pounds. At this point, the shafts could no longer be manually rotated. The adapter valve was filled with water at ambient temperature, and the valve was pressurized using a cylinder of nitrogen gas. Leakage from the stem seals was observed visually.

Test Procedure

Static leak testing of stem seals was accomplished with the adapter valve full of water at ambient temperature and using nitrogen cover gas. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi, and from 1250 psi to 1500 psi in increments of 50 psi. Each

increment of pressure was maintained for 5 minutes and stem-seal leakage was observed visually. As leakage was observed, the torque on the seal adjusting nut was increased until the leakage stopped. However, stem rotatability was still maintained. The test was then repeated starting at the pressure increment at which the leakage was observed.

Although the two adapter-valve stem seals are identical, their application differs. One seal is used in a rotary application only, while the second combines linear and rotary motion. Dynamic leak testing of the stem seals was accomplished as follows:

The ball-stem seal was tested with the adapter valve full of water at ambient temperature and nitrogen cover gas. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi, and from 1250 psi to 1500 psi in increments of 50 psi. At each pressure increment the stem, with the Geneva disengaged and the wedge full-up, was rotated through ten opening and closing cycles. The torque required for each rotation was recorded and stem leakage was visually checked.

The wedge-stem seal was tested with the adapter valve full of water at ambient temperature and nitrogen cover gas. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi and from 1250 psi to 1500 psi in increments of 50 psi. At each increment of pressure the wedge stem, with the Geneva disengaged and the ball open, was cycled through its engaged and disengaged cycles ten times. The breakaway torque required for each cycle was recorded and leakage was visually checked.

Test Discussion

The tightening torque applied to the adjusting nut of each steam was established during the static leak testing of the seals. This torque was determined to be 350 inch-pounds for each seal to ensure that any leakage was within the specification requirements. In this condition, no leakage was observed from either seal during both the static-and dynamic-leak tests.

The seals were continually checked for leakage during the ball-seal leakage tests. No leakage was observed. The stem seals performed well up to the point at which excessive leakage was observed (after 35 pressure cycles and 145 dynamic cycles). These cycles were completed during both the stem-seal and ball-seal leak tests. A pressure cycle consisted of increasing the adapter valve test pressure from zero to 1500 psig and decreasing the pressure to zero psi. A dynamic cycle consisted of rotating the ball- or wedge-shaft through its operating cycle. A typical failure of each seal consisted of the collapse of both the sealing surfaces of the dynamic gasket and the gasket deflector ring. An incident occurred during the ball seal leak tests which may have contributed to the failure of the stem seals.

Test Data

DATE 3-2-68SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAT. GASPARINOTEST TITLE INITIAL STEM SEALLEAKAGE TESTSN₂ PURGE PRESS. _____

Test No.	Time of Test	SEAL UNDER TEST	VISIBLE LEAKAGE	TEST PRESS.	TEST TEMP.				REMARKS
1	5 MIN	WEDGE STEM SEAL	NONE	250	AMB.				SEAL TORQUED TO 120 IN. LBS.
2	"	"	SEVERE BUBBLING	400	"				" " " " "
3	"	"	NONE	500	"				SEAL TORQUE INCREASED TO 300 IN. LBS.
4	"	"	"	750	"				" " "
5	"	"	"	1000	"				" " "
6	"	"	"	1250	"				" " "
7	"	"	"	1300	"				" " "
8	"	"	"	1400	"				" " "
9	"	"	"	1450	"				" " "
10	"	"	"	1500	"				" " "
11	"	BALL STEM SEAL	NONE	250	"				SEAL TORQUED TO 120 IN. LBS.
12	"	"	SEVERE BUBBLING	400	"				" " " " "
13	"	"	NONE	500	"				SEAL TORQUE INCREASED TO 300 IN. LBS.
14	"	"	"	750	"				" " " " "
15	"	"	"	1000	"				" " " " "
16	"	"	"	1250	"				" " " " "
17	"	"	"	1300	"				" " " " "
18	"	"	"	1400	"				" " " " "
19	"	"	"	1450	"				" " " " "
20	"	"	"	1500	"				" " " " "
21									" " " " "

DATE 3-3-62SHIFT 2NDSUPERVISOR W. MENNONNATECHNICIANS G. MEIERC. DELVECCHIOTEST TITLE STEM SEAL STATILLEAK TESTN₂ PURGE PRESS. _____ PAGE 1 OF 2

Test No.	Time of Test	TEST TEMP	TEST PRESS.	VISIBLE LEAKAGE		TORQUE ON SEAL		REMARKS
				BALL STEM SEAL	WEDGE STEM SEAL	BALL STEM SEAL	WEDGE STEM SEAL	
1	5 MIN	"	250	NONE	NONE	250 IN. LB	250 IN. LB	TORQUE ON THE STEM SEALS WAS DROPPED FROM 350 IN. LBS TO 250 IN. LBS. AT THE START OF THIS TEST
2	"	"	500	"	"	"	"	
3	"	"	750	"	"	"	"	
4	"	"	1000	"	"	"	"	
5	"	"	1250	"	"	"	"	
6	"	"	1300	"	"	"	"	
7	"	"	1350	"	"	"	"	
8	"	"	1400	"	"	"	"	
9	"	"	1450	"	"	"	"	
10	10 MIN	"	1500	"	"	"	"	
11	5 MIN	"	250	NONE	"	200 IN. LB	250 IN. LB	
12	"	"	500	SLIGHT BUBBLING	"	"	"	
13	"	"	750	"	"	"	"	
14	"	"	1000	SEVERE BUBBLING	"	"	"	
15	"	"	1250	"	"	"	"	
16	"	"	1300	"	"	"	"	
17	"	"	1350	"	"	"	"	
18	"	"	1400	"	"	"	"	
19	"	"	1450	"	"	"	"	
20	"	"	1500	"	"	"	"	
21		"			"			

DATE 3-6-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAT. GASPARINOTEST TITLE STEM SEAL LEAKAGETESTSN₂ PURGE PRESS. _____

Test No.	Time of Test	SEAL UNDER TEST	VISIBLE LEAKAGE	TEST PRESS.	TEST TEMP.				REMARKS
1	5 MIN.	WEDGE STEM SEAL	NONE	250	AMB.				SEAL TORQUED TO 200 IN. LBS.
2	"	"	SEVERE BUBBLING	500	"				SEAL TORQUE INCREASED TO 300 IN. LBS.
3	"	"	NONE	750	"				
4	"	"	SLIGHT BUBBLING	1000	"				SEAL TORQUE INCREASED TO 350 IN. LBS.
5	"	"	NONE	1250	"				
6	"	"	"	1300	"				
7	"	"	"	1350	"				
8	"	"	"	1400	"				
9	"	"	"	1450	"				
10	"	"	"	1500	"				
11									
12	5 MIN.	BALL STEM SEAL	NONE	250	AMB.				SEAL TORQUED TO 100 IN. LBS.
13	"	"	SEVERE BUBBLING	500	"				SEAL TORQUE INCREASED TO 300 IN. LBS.
14	"	"	NONE	750	"				
15	"	"	NONE	1000	"				
16	"	"	NONE	1250	"				
17	"	"	SLIGHT BUBBLING	1300	"				SEAL TORQUE INCREASED TO 350 IN. LBS.
18	"	"	NONE	1350	"				
19	"	"	"	1400	"				
20	"	"	"	1450	"				
21	"	"	"	1500	"				

BALL-SEAL LEAK TESTS
AMBIENT TEMPERATURE, OPERATING-PRESSURE

Test Equipment and Instrumentation.

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
Electrolytic Hygrometer	Beckman Instrument	Indicate magnitude of water leakage in ppm.
Dessicant Containers	AMF Laboratories	Determine magnitude of water leakage in grams.
Torque Wrench	Sturtevant	Set torque on wedge shaft.
Drive Shaft	AMF Laboratories	To adapt torque wrench to the wedge shaft.

Test Setup

With the ball closed, leak testing of the adapter valve was conducted by filling the reactor side of the valve with water at ambient temperature. Nitrogen gas, the pressurizing medium was piped into this side of the valve. Various tightening torques were applied to the wedge shaft to supply a seating force to the ball-valve, graphite-seat device. Leakage was collected in the test chamber on the machine side of the ball valve. Nitrogen gas was piped into the top of the test chamber. The purpose of this nitrogen supply was to provide 15 psi carrier gas through the test chamber. The nitrogen gas was directed across the ball-seal face and out the bottom of the chamber into a leakage detection device. Water leakage past the ball seal and into the test chamber was picked up by the 15 psi nitrogen-purge and the nitrogen-water mixture was absorbed in the leakage detecting device. The water in the nitrogen-water mixture was absorbed by the desiccant and dried nitrogen was vented to atmosphere. The difference in weight of the desiccant container before and after testing represented water absorption directly

proportional to the leak rate. When the electrolytic hygrometer was used to detect the leakage, the nitrogen-water mixture passed across a sensitive cell within the instrument and the amount of water present in the mixture was indicated in ppm of the flowing mixture.

Test Procedure

The ball valve was closed using a torque wrench and special drive shaft. After the ball was rotated 90 degrees and seated, wedge-shaft rotation continued until the wedge was lowered. The rotation of the drive shaft was stopped when a specified torque was reached. The upstream or reactor side of the adapter valve was then filled with water at ambient temperature and atmospheric pressure.

Using nitrogen gas, the water-filled-section pressure was increased from atmospheric to 1250 psi in increments of 250 psi and from 1250 psi to 1500 psi in 50 psi increments. At each pressure increment, a ten-minute leakage check was made and the leakage data obtained was collected and recorded. Upon reaching a pressure of 1500 psi, a second test was conducted by decreasing the pressure from 1500 psi to atmospheric pressure in the same increments with leakage data being obtained at each pressure increment.

During all ball-seal-leakage tests, the stem seals were monitored for signs of leakage.

Test Discussion

Ball-seal leakage tests were conducted under varying conditions of wedge-shaft actuating torque. Leakage data was obtained at three different torque settings: 10 foot-pounds, 15 foot-pounds, and 20 foot-pounds. The leakage rates obtained under each of the three wedge-actuating-torque conditions were well below the maximum acceptable leakage rate of 300 cc per hour. With a torque of ten foot-pounds applied to the shaft, the average

leak rate was 9 cc per hour. A torque of 15 foot-pounds resulted in a leak rate 16 cc per hour at 250 psi and a low rate of 1.6 cc per hour at 1500 psi.

Ten leakage tests were conducted with a torque of 20 foot-pounds applied to the drive shaft of the actuating mechanism. The average leakage rate at each pressure increment for the entire ten-cycle test is shown below:

<u>PRESSURE (PSIG)</u>	<u>LEAKAGE IN CC. PER HOUR</u>
0	2.1
250	2.3
500	2.4
750	2.6
1000	2.8
1250	2.9
1300	2.7
1350	2.7
1400	2.8
1450	2.9
1500	3.0

At the conclusion of the ten-cycle ball-seal-leak test, the adapter valve was disassembled and the components of the ball seal assembly were inspected. The graphite seat and ball- and wedge-shafts were in excellent condition. The clamp ring, wedge, and the spacer ring also showed no evidence of scoring, scratching or distortion. However, ball surface was scratched in several places. The scratches were attributed to the sharp edges of the water-circulating slots cut in the clamp ring spherical surface. The edges of these slots had previously been stoned. However, as the ball material was relatively softer than the chrome-plated surface of the clamp ring, scratching occurred at the points of contact.

The ball sealing surface was polished with fine crocus cloth, the edges of the slots in clamp ring were again stoned, and the valve was re-assembled for further testing.

AMF-388-TR-3

Test Data

AMERICAN MACHINE
&
FOUNDRY COMPANY

TEST DATA SHEET

PAGE 1 OF 1

PROJECT TITLE CANDUPROJ. NO.
A 3881753-8-62
W. N. MENNONNA
DAY SHIFTTEST WEDGE STEM SEAL LEAKAGE TEST
UNDER DYNAMIC CONDITIONS

NOTES BALL FULL OPEN - GENEVA REMOVED - WEDGE SHAFT ROTATED
180° CW AND CCW AND BREAKAWAY TORQUE RECORDED.

CYCLE NO	AVG. OF 10 CYCLES BREAK- AWAY TORQUE	TEST TEMP.	TEST PRESS.	WEDGE STEM SEAL VISIBLE LEAKAGE	REMARKS		
1 CW	20 IN. LBS	AMB.	AMB.	NONE	TORQUE ON WEDGE STEM SEAL IS 250 IN. LBS.		
1 CCW	5 IN. LBS	"	AMB.	"	CW = CLOCKWISE CCW = COUNTERCLOCKWISE		"
2 CW	18 IN. LBS	"	250	STEADY STREAM	INCREASED TORQUE ON THE STEM SEAL FROM 250 IN. LBS TO 350 IN. LBS		
2 CCW	10 IN. LBS	"	250	NONE			
3 CW	15 IN. LBS	"	500	"			
3 CCW	10 IN. LBS	"	500	"			
4 CW	16 IN. LBS	"	750	SLIGHT LEAKAGE	INCREASED TORQUE ON THE STEM SEAL FROM 350 IN. LBS TO 360 IN. LBS.		
4 CCW	10 IN. LBS	"	750	NONE			
5 CW	18 IN. LBS	"	1000	NONE			
5 CCW	10 IN. LBS	"	1000	"			
6 CW	19 IN. LBS	"	1250	1 DROP	LEAKED ONE DROP WHEN WEDGE WAS GOING DOWN.		
6 CCW	10 IN. LBS	"	1250	NONE			
7 CW	20 IN. LBS	"	1300	NONE			
7 CCW	10 IN. LBS	"	1300	NONE			
8 CW	21 IN. LBS	"	1350	2 DROPS	LEAKED TWO DROPS WHEN WEDGE WAS GOING DOWN.		
8 CCW	12 IN. LBS	"	1350	NONE			
9 CW	22 IN. LBS	"	1400	NONE			
9 CCW	13 IN. LBS	"	1400	"			
10 CW	20 IN. LBS	"	1450	"			
10 CCW	13 IN. LBS	"	1450	"			
11 CW	22 IN. LBS	"	1500	"			
11 CCW	13 IN. LBS	"	1500	"			

RECORDED BY

DATE

INSTRUMENTS

WITNESSED BY

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AMERICAN MACHINE
&
FOUNDRY COMPANY

TEST DATA SHEET

PAGE 1 OF 1PROJECT TITLE CANDU

PROJ. NO.

A388175

3-8-62

W. N. MENNONNA
DAY SHIFTTEST BALL STEM SEAL LEAKAGE TEST
UNDER DYNAMIC CONDITIONS

NOTES WEDGE FULLY RETRACTED - BALL ROTATED CW & CCW 90°
AND BREAKAWAY TORQUE RECORDED

CYCLE NO.	AVG. OF 10 CYCLES BREAK- AWAY TORQUE	TEST TEMP.	TEST PRESS.	BALL STEM SEAL VISIBLE LEAKAGE	REMARKS		
1 CCW	47.5 ^{IN} LBS.	AMB.	AMB	NONE	TORQUE ON BALL STEM		
1 CW	61.7 ^{IN} LBS.	"	AMB	"	SEAL IS 350 IN. LBS.		
2 CCW	45.7 ^{IN} LBS	"	250	"	CW = CLOCKWISE		
2 CW	52.2 ^{IN} LBS	"	250	"	CCW = COUNTERCLOCKWISE		
3 CCW	65.0 ^{IN} LBS	"	500	"			
3 CW	74.0 ^{IN} LBS	"	500	"			
4 CCW	10.0 ^{FT} LBS	"	750	"			
4 CW	5.0 ^{FT} LBS	"	750	"			
5 CCW	10.0 ^{FT} LBS	"	1000	"			
5 CW	10.0 ^{FT} LBS	"	1000	"			
6 CCW	15.0 ^{FT} LBS	"	1250	"			
6 CW	10.0 ^{FT} LBS	"	1250	"			
7 CCW	15.0 ^{FT} LBS	"	1300	"			
7 CW	10.0 ^{FT} LBS	"	1300	"			
8 CCW	15.0 ^{FT} LBS	"	1350	"			
8 CW	10.0 ^{FT} LBS	"	1350	"			
9 CCW	20.0 ^{FT} LBS	"	1400	"			
9 CW	10.0 ^{FT} LBS	"	1400	"			
10 CCW	15.0 ^{FT} LBS	"	1450	"			
10 CW	10.0 ^{FT} LBS	"	1450	"			
11 CCW	17.5 ^{FT} LBS	"	1500	"			
11 CW	15.0 ^{FT} LBS.	"	1500	"			

RECORDED BY

DATE

INSTRUMENTS

WITNESSED BY

43

DATE 3-2-62
 SHIFT 2ND
 SUPERVISOR J. EDSON

TECHNICIANS G. MEIER
C. DELVECCHIO

TEST TITLE INITIAL BALL SEAL
LEAK TEST
 N2 PURGE PRESS. _____

Test No.	Time of Test	SEAL UNDER TEST	VISIBLE LEAKAGE IN ML	LEAKAGE IN CC/HR	TEST PRESS.	TEST TEMP.	REMARKS		
1	5 MIN.	BALL SEAL	.5	6	250	AMB.	WEDGE TORQUED TO 10 FT. LBS.		
2	"	"	.8	9.6	500	"	"	"	"
3	"	"	1.1	13.2	750	"	"	"	"
4	"	"	1.0	12.0	1000	"	"	"	"
5	"	"	.5	6	1250	"	"	"	"
6	"	"	.8	9.6	1300	"	"	"	"
7	"	"	.8	9.6	1350	"	"	"	"
8	"	"	.6	7.2	1400	"	"	"	"
9	"	"	.7	8.4	1450	"	"	"	"
10	"	"	.7	8.4	1500	"	"	"	"
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

DATE 3-7-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAT. CRASPARINOTEST TITLE BALL SEAL LEAKAGETESTN₂ PURGE PRESS. 5 PSI

Test No.	Time of Test	SEAL UNDER TEST	DESICCANT WT. BEFORE TEST	DESICCANT WT. AFTER TEST	LEAKAGE IN CC/HR	TEST. PRESS.	TEST TEMP	DESICCANT NO.	REMARKS
1	10 MIN.	BALL SEAL	282.5950	283.6044	16.2	250	AMB	1	TORQUE ON WEDGE SET AT 15 FT. LBS
2	"	"	296.1007	296.5335	7.0	500	"	2	
3	"	"	277.1615	277.5950	7.0	750	"	3	
4	"	"	274.3755	274.6015	3.7	1000	"	4	
5	"	"	303.1465	303.4322	3.8	1250	"	5	
6	"	"	288.7955	288.9504	2.6	1300	"	6	
7	"	"	283.5760	283.8052	3.7	1350	"	1	
8	"	"	296.5065	296.7385	3.7	1400	"	2	
9	"	"	277.5780	277.7980	3.6	1450	"	3	
10	"	"	274.5840	274.6261	0.8	1500	"	4	
11	"	"	303.4130	303.5001	1.5	1500	"	5	
12	"	"	288.9388	289.0314	1.6	1500	"	6	
13									
14									
15									
16									
17									
18									
19									
20									
21									

DATE 3-7-62SHIFT DAY & NIGHTSUPERVISOR W. MENNONNA
T. MASONTECHNICIANS W. RAILA - G. MEIERC. DELVECCHIOT. GASPARINOTEST TITLE BALL SEAL LEAK TESTUSING HYGROMETERN₂ PURGE PRESS. 15 PSLN₂ = 10 PPM1 OF 4

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE IN PPM	LEAKAGE IN CC/HR	TEST PRESS.	TEST TEMP.	REMARKS		
1	START	BALL SEAL	200	1.2	1500	AMB	TORQUE ON WEDGE SET AT 20 FT. LBS.		
2	10 MIN	"	205	1.2	1500	"			
3	START	"	210	1.3	1500	"			
4	10 MIN	"	200	1.2	1500	"			
5	START	"	180	1.1	1450	"	2ND SHIFT TOOK OVER.		
6	10 MIN	"	140	0.8	1450	"			
7	START	"	140	0.8	1400	"			
8	10 MIN	"	130	0.8	1400	"			
9	START	"	130	0.8	1350	"			
10	10 MIN	"	150	0.9	1350	"			
11	START	"	150	0.9	1300	"			
12	10 MIN	"	140	0.8	1300	"			
13	START	"	140	0.8	1250	"			
14	10 MIN	"	140	0.8	1250	"			
15	START	"	140	0.8	1200	"			
16	10 MIN	"	130	0.8	1200	"			
17	START	"	130	0.8	1150	"			
18	10 MIN	"	120	0.7	1150	"			
19	START	"	120	0.7	900	"			
20	10 MIN	"	120	0.7	900	"			
21		"				"			

NO VISIBLE LEAKAGE AT STEAM SEALS OR CHAMPS

TEST TITLE BALL SEAL LEAK TEST
- USING HYGROMETER
 N₂ PURGE PRESS. 15 PSIG
N₂ = 100PPM 20

[illegible]

DATE 3-7-62
 SHIFT 2ND
 SUPERVISOR T. MASON

TECHNICIANS G. MEIER
C. DELVECCHIO

TEST TITLE BALL SEAL LEAK TEST
USING HYGROMETER

N₂ PURGE PRESS. 15 PSL
N₂ = 10 PPM

3 of 4

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE IN P.P.M.	LEAKAGE IN CC/HR	TEST PRESS.	TEST TEMP	REMARKS		
1	START	BALL SEAL	70	0.4	1350	AMB.	TORQUE ON WEDGE SET AT 20 FT. LBS.		
2	10 MIN	"	70	0.4	1350	"			
3	START	"	70	0.4	1400	"			
4	10 MIN	"	74	0.4	1400	"			
5	START	"	72	0.4	1450	"			
6	10 MIN	"	74	0.4	1450	"			
7	START	"	74	0.4	1500	"			
8	10 MIN	"	74	0.4	1500	"			
9	START	"	72	0.4	1450	"			
10	10 MIN	"	72	0.4	1450	"			
11	START	"	72	0.4	1400	"			
12	10 MIN	"	74	0.4	1400	"			
13	START	"	76	0.5	1350	"			
14	10 MIN	"	80	0.5	1350	"			
15	START	"	80	0.5	1300	"			
16	10 MIN	"	72	0.4	1300	"			
17	START	"	78	0.5	1250	"			
18	10 MIN	"	74	0.4	1250	"			
19	START	"	76	0.5	1000	"			
20	10 MIN	"	76	0.5	1000	"			
21									

IN INSIDE LEAKAGE AT STEEL SEAL

DATE 3-7-62
 SHIFT 2ND
 SUPERVISOR T. MASON

TECHNICIANS G. MEIER
C. DELVECCHIO

TEST TITLE BALL SEAL LEAK TEST
USING HYGROMETER
 N2 PURGE PRESS. 15 PSI
N2 = 10 PPM 4.94

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE IN P.P.M.	LEAKAGE IN CC/HR	TEST PRESS.	TEST TEMP.			REMARKS
1	START	BALL SEAL	76	0.5	750	AMB.			TORQUE ON WEDGE SET AT 20 FT. LBS.
2	10 MIN	"	80	0.5	750	"			
3	START	"	82	0.5	500	"			
4	10 MIN	"	76	0.5	500	"			
5	START	"	74	0.4	250	"			
6	10 MIN	"	70	0.4	250	"			
7	START	"	70	0.4	0	"			
8	10 MIN	"	64	0.4	0	"			
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

VISIBLE LEAKAGE
 0.2 CC/HR/PS

DATE 3-12-62
 SHIFT 2ND
 SUPERVISOR N. MENNONNA

TECHNICIANS G. MEIER
C. DELVECHIO

TEST TITLE BALL SEAL LEAKAGE
TEST USING HYGROMETER
 N₂ PURGE PRESS. 15 PSI
 N₂ = 20 PPM

Test No.	Time of Test	SEAL UNDER TEST	HYGROMETER READING IN PPM	LEAKAGE IN CC/HR	TEST TEMP.	TEST PRESS.		REMARKS
1	START	BALL SEAL	420	2.5	AMB	1500		TORQUE ON WEDGE SET
2	10 MIN	"	420	2.5	"	1500		AT 20 FT. LBS
3	START	"	420	2.5	"	1450		
4	10 MIN	"	410	2.4	"	1450		LEAKAGE CC/HR = (HYGROMETER
5	START	"	410	2.4	"	1400		READING - 20) .006
6	10 MIN	"	420	2.5	"	1400		
7	START	"	420	2.5	"	1350		NO LEAKAGE OBSERVED FROM
8	10 MIN	"	440	2.6	"	1350		STEM SEALS, FORWARD CLAMP,
9	START	"	440	2.6	"	1300		OR GRAYLOC CLAMP
10	10 MIN	"	430	2.5	"	1300		THROUGHOUT TEST
11	START	"	430	2.5	"	1250		
12	10 MIN	"	420	2.5	"	1250		
13	START	"	420	2.5	"	1000		
14	10 MIN	"	430	2.5	"	1000		
15	START	"	430	2.5	"	750		
16	10 MIN	"	430	2.5	"	750		
17	START	"	430	2.5	"	500		
18	10 MIN	"	410	2.4	"	500		
19	START	"	410	2.4	"	250		
20	10 MIN	"	410	2.4	"	250		
21	START	"	400	2.3	"	0		

DATE 3-12-62SHIFT 2NDSUPERVISOR W. MENNONNATECHNICIANS G. MEIERC. DELVECCHIOTEST TITLE BALL SEAL LEAKAGETEST USING HYGROMETERN₂ PURGE PRESS. 15 PSLN₂ = 20 PPM

Test No.	Time of Test	SEAL UNDER TEST	HYGROMETER READING IN PPM.	LEAKAGE IN CC/HR	TEST TEMP.	TEST PRESS.	REMARKS
1	10 MIN.	BALL SEAL	400	2.3	AMB.	0	TORQUE ON WEDGE SET
2	START	"	400	2.3	"	250	AT 20 FT. LBS
3	10 MIN.	"	400	2.3	"	250	
4	START	"	400	2.3	"	500	LEAKAGE CC/HR = (HYGROMETER
5	10 MIN.	"	390	2.2	"	500	READING - 20) .006
6	START	"	390	2.2	"	750	
7	10 MIN.	"	390	2.2	"	750	NO LEAKAGE OBSERVED
8	START	"	390	2.2	"	1000	FROM STEM SEALS, FORWARD
9	10 MIN.	"	400	2.3	"	1000	CLAMP, OR GRAYLOC CERT.
10	START	"	400	2.3	"	1250	THROUGHOUT TEST
11	10 MIN.	"	410	2.4	"	1250	
12	START	"	410	2.4	"	1300	
13	10 MIN.	"	410	2.4	"	1300	
14	START	"	410	2.4	"	1350	
15	10 MIN.	"	410	2.4	"	1350	
16	START	"	410	2.4	"	1400	
17	10 MIN.	"	420	2.5	"	1400	
18	START	"	420	2.5	"	1450	
19	10 MIN.	"	420	2.5	"	1450	
20	START	"	420	2.5	"	1500	
21	10 MIN.	"	420	2.5	"	1500

AMERICAN MACHINE
&
FOUNDRY COMPANY

TEST DATA SHEET

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PROJECT TITLE CANDU

PROJ. NO.

TEST BALL SEAL LEAKAGEA388175NOTES HYGROMETER USED TO RECORD LEAKAGEN₂ = 150 PPM

LEAKAGE IN CC/HR = (HYGROMETER READING - 150) .006

SEAL UNDER TEST	TEST TEMP.	TEST PRESS.	HYGRO-METER READING	LEAKAGE IN CC/HR	TIME OF TEST RUN	REMARKS
BALL SEAL	AMB	0	250	.6	START	WEDGE TORQUE
" "	"	0	270	.7	10 MIN	SET AT 20 FT. LBS
" "	"	250	270	.7	START	
" "	"	250	500	2.1	10 MIN	
" "	"	500	500	2.1	START	
" "	"	500	550	2.5	10 MIN	
" "	"	750	560	2.5	START	
" "	"	750	700	3.3	10 MIN	
" "	"	1000	720	3.4	START	
" "	"	1000	910	4.6	10 MIN	
" "	"	1250	930	4.7	START	
" "	"	1250	1000	5.1	10 MIN	REMOVED AND DRIED OUT TEST CHAMBER
" "	"	1300	360	1.3	START	TEST RESUMED
" "	"	1300	390	1.4	10 MIN	
" "	"	1350	390	1.4	START	
" "	"	1350	420	1.7	10 MIN	
" "	"	1400	430	1.7	START	
" "	"	1400	510	2.2	10 MIN	
" "	"	1450	510	2.2	START	
" "	"	1450	590	2.6	10 MIN	
" "	"	1500	590	2.6	START	
" "	"	1500	620	2.9	10 MIN	

RECORDED BY
W. MENNONNA

DATE
3-13-62
2ND
SHIFT

INSTRUMENTS

WITNESSED BY G. MEIER
C. DELVECCHIO

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AMERICAN MACHINE
&
FOUNDRY COMPANY

TEST DATA SHEET

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PROJECT TITLE CANDU

PROJ. NO.

TEST BALL SEAL LEAKAGEA388175NOTES HYGROMETER USED TO RECORD LEAKAGEN₂ = 150 PPM

LEAKAGE IN CC/HR = (HYGROMETER READING - 150) * 0.006

SEAL UNDER TEST	TEST TEMP.	TEST PRESS.	HYGROMETER READING	LEAKAGE IN CC/HR	TIME OF TEST RUN	REMARKS		
BALL SEAL	AMB.	0	985	5.0	10 MIN	WEDGE	TORQUE	SET
" "	"	0	985	5.0	START	AT 20	FT. LBS.	
" "	"	250	980	5.0	10 MIN			
" "	"	250	980	5.0	START	TEST	STARTED AT	
" "	"	500	980	5.0	10 MIN	1500 PSI.	DOWN TO	
" "	"	500	995	5.1	START	"0" PSI.		
" "	"	750	995	5.1	10 MIN			
" "	"	750	995	5.1	START			
" "	"	1000	995	5.1	10 MIN			
" "	"	1000	980	5.0	START			
" "	"	1250	980	5.0	10 MIN			
" "	"	1250	910	4.6	START			
" "	"	1300	910	4.6	10 MIN			
" "	"	1300	830	4.1	START			
" "	"	1350	830	4.1	10 MIN			
" "	"	1350	720	3.4	START			
" "	"	1400	720	3.4	10 MIN			
" "	"	1400	700	3.3	START			
" "	"	1450	700	3.3	10 MIN			
" "	"	1450	630	2.9	START			
" "	"	1500	630	2.9	10 MIN			
" "	"	1500	620	2.9	START			

RECORDED BY
W. MENNONNADATE
3-13-62
2ND
SHIFT

INSTRUMENTS

WITNESSED BY G. MEIER
C. DELVECCHIO

53

DATE 3-14-62
 SHIFT 2ND
 SUPERVISOR W. MENNONNA

TECHNICIANS G. MEIER
C. DELVECCHIO

TEST TITLE BALL SEAL LEAKAGE TEST
HYGROMETER USED
 N₂ PURGE PRESS. 35 PSI
 N₂ = 15 PPM

Test No.	Time of Test	SEAL UNDER TEST	HYGROMETER READING IN PPM	LEAKAGE IN CC/HR	TEST TEMP.	TEST PRESS		REMARKS
1	10 MIN	BALL SEAL	500	2.9	AMB.	0		WEDGE TORQUE SET AT
2	START	"	500	2.9	"	250		20 FT. LBS.
3	10 MIN	"	500	2.9	"	250		
4	START	"	500	2.9	"	500		LEAKAGE CC/HR = (HYGROMETER
5	10 MIN	"	500	2.9	"	500		READING - 15) .006
6	START	"	500	2.9	"	750		
7	10 MIN	"	540	3.2	"	750		BALL STEM SEAL LEAKED
8	START	"	540	3.2	"	1000		OBJECTIONABLY THROUGHOUT
9	10 MIN	"	600	3.5	"	1000		THE TEST
10	START	"	600	3.5	"	1250		
11	10 MIN	"	620	3.6	"	1250		
12	START	"	620	3.6	"	1300		
13	10 MIN	"	660	3.9	"	1300		
14	START	"	660	3.9	"	1350		
15	10 MIN	"	700	4.1	"	1350		
16	START	"	700	4.1	"	1400		
17	10 MIN	"	720	4.2	"	1400		
18	START	"	720	4.2	"	1450		
19	10 MIN	"	730	4.3	"	1450		
20	START	"	730	4.3	"	1500		
21	10 MIN	"	740	4.4	"	1500		

DATE 3-14-62SHIFT ENDSUPERVISOR W. MENNONNATECHNICIANS G. MEIERC. DELVECCHIOTEST TITLE BALL SEAL LEAKAGE TEST -
HYGROMETER USED.N₂ PURGE PRESS. 35 PSIN₂ = 15 PPM

Test No.	Time of Test	SEAL UNDER TEST	HYGROMETER READING PPM	LEAKAGE IN CC/HR	TEST TEMP.	TEST PRESS.			REMARKS
1	START	BALL SEAL	420	2.4	AMB.	0			WEDGE TORQUE SET AT
2	10 MIN	"	420	2.4	"	0			20 FT. LBS
3	START	"	420	2.4	"	250			LEAKAGE CC/HR = (HYGROMETER
4	10 MIN	"	410	2.4	"	250			READING - 15) .006
5	START	"	410	2.4	"	500			
6	10 MIN	"	440	2.6	"	500			BALL STEM SEAL LEAKED
7	START	"	440	2.6	"	750			OBJECTIONABLY THROUGHOUT
8	10 MIN	"	500	2.9	"	750			THE TEST
9	START	"	500	2.9	"	1000			
10	10 MIN	"	560	3.3	"	1000			
11	START	"	560	3.3	"	1250			
12	10 MIN	"	560	3.3	"	1250			
13	START	"	560	3.3	"	1300			
14	10 MIN	"	660	3.9	"	1300			
15	START	"	660	3.9	"	1350			
16	10 MIN	"	630	3.7	"	1350			
17	START	"	630	3.7	"	1400			
18	10 MIN	"	700	4.1	"	1400			
19	START	"	700	4.1	"	1450			
20	10 MIN	"	720	4.2	"	1450			
21	START	"	720	4.2	"	1500			

DATE 3-14-62SHIFT 2NDSUPERVISOR W. MENNONNATECHNICIANS G. MEIERC. DELVECCHIOTEST TITLE BALL SEAL LEAKAGE TESTHYGROMETER USEDN2 PURGE PRESS. 35 PSIN2 @ 15 PPM

Test No.	Time of Test	SEAL UNDER TEST	HYGROMETER READING IN PPM	LEAKAGE IN CC/HR	TEST TEMP.	TEST PRESS.		REMARKS
1	10 MIN.	BALL SEAL	190	1.1	AMB	0		WEDGE TORQUE SET AT
2	START	"	190	1.1	"	250		20 FT. LBS
3	10 MIN	"	220	1.2	"	250		LEAKAGE IN CC/HR = (HYGROMETER
4	START	"	220	1.2	"	500		READING - 15) .006
5	10 MIN	"	240	1.4	"	500		
6	START	"	240	1.4	"	750		BALL STEM SEAL LEAKED
7	10 MIN	"	290	1.7	"	750		OBJECTIONABLY THROUGHOUT
8	START	"	290	1.7	"	1000		THE TEST
9	10 MIN	"	380	2.2	"	1000		
10	START	"	380	2.2	"	1250		
11	10 MIN	"	500	2.9	"	1250		
12	START	"	500	2.9	"	1300		
13	10 MIN	"	600	3.5	"	1300		
14	START	"	600	3.5	"	1350		
15	10 MIN	"	700	4.1	"	1350		
16	START	"	700	4.1	"	1400		
17	10 MIN	"	790	4.7	"	1400		
18	START	"	790	4.7	"	1450		
19	10 MIN	"	900	5.3	"	1450		
20	START	"	900	5.3	"	1500		
21	10 MIN	"	980	5.8	"	1500		

PNEUMATIC MOTOR TESTS

A basic tenet of the adapter valve design is the ability to exert sufficient force through the wedge system to the ball-seal to efficiently seal the reactor fluid. This requirement holds through the entire operating ranges experienced by the reactor. This force should be accurately repeatable in order to control the seal leakage during the life of the valve assembly. The reference design uses a pressurized CO₂-driven pneumatic motor to apply a force through a gear system into the wedge.

Tests were necessary to determine if the pneumatic-motor principle as applied will perform as planned.

Test Equipment and Instrumentation

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
1. CO ₂ Cylinder	Air Reduction Company	Actuating gas for motors.
2. Pressure Regulator	Matheson Company	Vary gas pressure to pneumatic motors.
3. Pulley and Weight System	AMF Laboratories and Model Shop	Vary motor load in order to calibrate and test motor.

Test Setup

A simple test stand was constructed on which the pneumatic motor was mounted. A cylinder of CO₂ gas was connected to the inlet and exhaust ports of the motor. A pressure regulator was located on the outlet of the CO₂ cylinder. A manually-operated, two-way valve was installed in the inlet and exhaust lines. A pulley with a 3-inch radius was mounted on the motor shaft.

One end of a stainless-steel-wire cable was attached to the pulley; a weight hanger was attached to the other end of the wire cable. The pulley-and-weight system simulated the various motor loads required to calibrate and test

the motor. The CO₂ pressure regulator was set to supply a 125 psig CO₂ pressure to the motor. The test was started with the motor referenced for ball-actuating mechanism operation.

Test Procedure

The purpose of this test was to establish needle valve settings so that the motor would stall at an output torque of 20 foot-pounds when actuated by the system design pressure of 125 psig.

With the required weights placed on the hanger simulating the desired motor load, the motor was actuated by the 125 psig CO₂ pressure. With the motor running, the needle valves were manipulated in an attempt to set the motor stall torque at 20 foot-pounds, in both directions of rotation. Once accomplished, the motor would be mounted on the adapter-valve-ball-actuating mechanism. The ball-actuating mechanism would then be operated through 50 cycles, driving the wedge down until the motor stalled at 20 foot-pounds, then, by reversing the motor, lifting the wedge and reopening the ball. The entire ball actuating mechanism would be checked for capability and repeatability of operation.

Test Discussion

Test results of the ball-actuating-mechanism pneumatic motor, and torque turning requirements of the ball-seal-actuating system indicated that the motor was oversized for this particular application. The needle valves could not be set so that the motor would stall under a load of 20 foot-pounds when the motor actuating pressure was 125 psig. With a motor load of 20 foot-pounds, and both needle valves fully closed, the system design pressure of 125 psig accelerated the motor rapidly to 60 RPM. Enlarging the metering screw size from 3/8-16 to 7/16-20 did not afford better motor control. The motor would still not stall at 125 psig with a load of 20 foot-pounds and the metering screws fully closed.

With a load of 20 foot-pounds on the motor shaft and both metering valves closed, the motor could only be stalled by decreasing the CO₂ pressure to 40 psig.

This motor was mounted on the adapter-valve-ball-actuating mechanism and the 50-cycle ball-actuation test was conducted by operating the motor with a CO₂ pressure of 40 psig. Five cycles were successfully completed. During the sixth cycle, the wedge appeared to have seized in the down position. The wedge material in the area of the wedge-to-wedge shaft attachment failed in shear (figure 7). This failure became evident when efforts to open the ball were unsuccessful, in order to complete the sixth cycle. Damage to various components of the ball actuating mechanism resulted. With the wedge stuck in the down position the ball was not free to rotate, and the force developed by the pneumatic motor was absorbed by the components (figure 8) of the ball-actuating mechanism. As a result, the following components of the ball-actuating mechanism were damaged:

- a. Geneva lock — severe galling..
- b. Ball shaft key — compressed out of shape.
- c. Wormwheel — Geneva drive pin hole became elongated.

It was now obvious that the reference pneumatic motor was too powerful for this application. Particularly since accurate control with the needle valve was not possible. A smaller capacity motor was obtained to continue testing the use of a pneumatic device to operate the ball-actuating mechanism. A motor having approximately one-quarter the power of the reference motor was obtained for testing. This motor had approximately 25 per cent more power when rotating in the clockwise direction. The vendor indicated that this same motor, having equal power in both directions of rotation was available. The motor appeared to provide sufficient power, reasonable control and stall torque regulation for use on the ball-actuating mechanism.

A series of tests were conducted using the same test setup and test procedure. The test results indicated that the motor had a maximum torque output of 29 foot-pounds in the clockwise direction and 21 foot-pounds when

Figure 7. Initial Wedge Failure

Figure 8. Damaged Geneva Mechanism and Worm Wheel
Resulting from Initial Wedge Failure

rotating counterclockwise. These maximum values were obtained at 125 psig CO₂ pressure with both needle valves fully open. The motor control appeared acceptable as the stall torque could be varied an average of two foot-pounds torque by a one turn of the motor needle valves.

The adapter valve test program was continued by manually operating of the ball-actuating mechanism.

Test Data

DATE 5-2-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE TEST TO DETERMINE OPERATING
CHARACTERISTICS OF CLECO AIR MOTOR
N₂ PURGE PRESS. P/N 14 RNS-4

Test No.	Time of Test	CO ₂ PRESS.	NO. OF TURNS NEEDLE VALVES OPEN	DIRECTION OF ROTATION	STALL TORQUE				REMARKS
1		125	1 TURN BOTH VALVES	CLOCKWISE CW	12 FT. LBS.				MOTOR OPERATED IN CLOCKWISE DIRECTION AS VIEWED FROM REAR OF THE MOTOR.
2		125	2 TURNS BOTH VALVES	CW	22				
3		125	3 TURNS BOTH VALVES	CW	23.5				
4		125	4 TURNS BOTH VALVES	CW	25				
5		100	1 TURN BOTH VALVES	CW	12				
6		100	2 TURNS BOTH VALVES	CW	19				
7		100	3 TURNS BOTH VALVES	CW	20				
8		100	4 TURNS BOTH VALVES	CW	22				
9		75	1 TURN BOTH VALVES	CW	10				
10		75	2 TURNS BOTH VALVES	CW	14				
11		75	3 TURNS BOTH VALVES	CW	16				
12		75	4 TURNS BOTH VALVES	CW	17				
13		50	1 TURN BOTH VALVES	CW	7				
14		50	2 TURNS BOTH VALVES	CW	8				
15		50	3 TURNS BOTH VALVES	CW	9				
16		50	4 TURNS BOTH VALVES	CW	11				
17									
18									
19									
20									
21									

DATE 5-3-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE TEST TO DETERMINE OPERATINGCHARACTERISTICS OF CLECO AIR MOTORN₂ PURGE PRESS. P/N 14 RNB

Test No.	Time of Test	CO ₂ PRESS.	NO. OF TURNS NEEDLE VALVES OPEN	DIRECTION OF ROTATION	STALL TORQUE				REMARKS
1		125	5 TURNS BOTH VALVES	CLOCKWISE CW	27				NEEDLE VALVES ARE FULL OPEN AT 6 TURNS
2		100	5 TURNS BOTH VALVES	CW	23.5				
3		75	5 TURNS BOTH VALVES	CW	18				
4		50	5 TURNS BOTH VALVES	CW	12				
5		125	6 TURNS BOTH VALVES	CW	29				
6		100	6 TURNS BOTH VALVES	CW	24.5				
7		75	6 TURNS BOTH VALVES	CW	19				
8		50	6 TURNS BOTH VALVES	CW	13				
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

5-3-62
W. H. H. H. H. H.

CLECO AIR MOTOR 14 RNS-4
STALL TORQUE $\frac{1}{2}$ CO₂ PRESSURE
(CW ROTATION)

NOTES
1. MOTOR NEEDLE VALVES
BOTH OPENED EQUALLY
AS INDICATED ON EACH
CURVE.

DATE 5-2-62TECHNICIANS W. RAILATEST TITLE TEST TO DETERMINE OPERATINGSHIFT DAYCHARACTERISTICS OF CLECO AIR MOTORSUPERVISOR W. MENNONNAN₂ PURGE PRESS. P/N 14 RNS-4

Test No.	Time of Test	CO ₂ PRESS.	NO. OF TURNS NEEDLE VALVES OPEN	DIRECTION OF ROTATION	STALL TORQUE				REMARKS
1		125	1 TURN BOTH VALVES	COUNTER- CLOCKWISE CCW	9 FT. LBS.				MOTOR OPERATED IN COUNTERCLOCKWISE DIRECTION AS VIEWED FROM REAR OF THE MOTOR.
2		125	2 TURNS BOTH VALVES	CCW	14				
3		125	3 TURNS BOTH VALVES	CCW	17				
4		125	4 TURNS BOTH VALVES	CCW	20				
5		100	1 TURN BOTH VALVES	CCW	9				
6		100	2 TURNS BOTH VALVES	CCW	13.5				
7		100	3 TURNS BOTH VALVES	CCW	16				
8		100	4 TURNS BOTH VALVES	CCW	19				
9		75	1 TURN BOTH VALVES	CCW	7				
10		75	2 TURNS BOTH VALVES	CCW	10				
11		75	3 TURNS BOTH VALVES	CCW	11.5				
12		75	4 TURNS BOTH VALVES	CCW	14				
13		50	1 TURN BOTH VALVES	CCW	5				
14		50	2 TURNS BOTH VALVES	CCW	6.5				
15		50	3 TURNS BOTH VALVES	CCW	7				
16		50	4 TURNS BOTH VALVES	CCW	9				
17									
18									
19									
20									
21									

DATE 5-3-62TECHNICIANS W. RAILATEST TITLE TEST TO DETERMINE OPERATINGSHIFT DAY

CHARACTERISTICS OF CLECO AIR MOTOR

SUPERVISOR W. MENNONNAN₂ PURGE PRESS. P/N 14RNS-4

Test No.	Time of Test	CO ₂ PRESS.	NO. OF TURNS NEEDLE VALVES OPEN	DIRECTION OF ROTATION	STALL TORQUE				REMARKS
1		125	5 TURNS BOTH VALVES	COUNTER-CLOCKWISE CCW	21				NEEDLE VALVES ARE FULL OPEN AT 6 TURNS.
2		100	5 TURNS BOTH VALVES	CCW	19.5				
3		75	5 TURNS BOTH VALVES	CCW	14.5				
4		50	5 TURNS BOTH VALVES	CCW	9.5				
5		125	6 TURNS BOTH VALVES	CCW	23				
6		100	6 TURNS BOTH VALVES	CCW	20.5				
7		75	6 TURNS BOTH VALVES	CCW	15.5				
8		50	6 TURNS BOTH VALVES	CCW	11				
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

5-2-62
W. MENNON

CLECO AIR MOTOR 14 RNS-4
STALL TORQUE VS CO₂ PRESSURE
(CCW ROTATION)

26
24
22
20
18
16
14
12
10
8
6
4
2

CO₂ PRESSURE P.S.I.

NOTES

1. MOTOR NEEDLE VALVES
BOTH OPENED EQUALLY
AS INDICATED ON EACH
CURVE.

ADAPTER VALVE HEATER ELEMENT TESTING

The heater element tests consisted of intermittent operation of the heater elements to increase the temperature of the empty adapter valve from room temperature to 600°F. The increase in valve-body temperature was to be accomplished at a maximum rate of 20°F per minute maintaining a temperature no greater than 50°F between the internal and external valve body surfaces. The test was initially conducted with an uninsulated valve body and finally with the valve body fully insulated.

Test Equipment and Instrumentation

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
Thermocouple	AMF Laboratory	Temperature sensors.
Surface Pyrometer	PYRO	Temperature sensors.
Recorder, 16-point	Wheelco	Record Temperatures.
Insulation	AMF Laboratory	Minimize heat loss.

Test Setup

The heater elements were mounted on the valve. The heaters were connected to a 550-volt secondary of a 30-KVA transformer. Thermocouples were mounted on internal and external valve surfaces (see figure 9) and connected to a 16-point temperature recorder.

Test Procedure

The heaters were energized with the valve uninsulated. Temperature was regulated manually through intermittent manipulation of the ON-OFF switch and monitored. Temperatures sensed by each thermocouple were recorded (see data sheets 27, 28 and 29). The valve was then insulated with

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO. _____

JOB ORDER NO. _____

CONTRACT NO. _____

ADAPTER VALVE
TOP VIEW

THEMOCOUPE LOCATIONS

Figure 9. Thermocouple Locations

70

PREPARED BY

A. J. BLATTER

DATE

CHECKED BY

DATE

CLASS

DIV.

NUMBER

MODEL

jury-rig fiberglass insulation. The tests were repeated and the temperatures sensed by each thermocouple recorded (see data sheets 30 through 35). Temperatures in the forward clamp area were sensed with a surface pyrometer because of the relative inaccessibility of the housing body.

Test Discussion

With the valve body uninsulated, a maximum temperature of 450°F was attained on the external valve surface. At this point the heat loss from the uninsulated valve exceeded the heater capacity.

With the valve body insulated with jury-rig fiberglass insulation, a temperature of 610°F was attained on the external valve surface. Temperature control for both tests was accomplished by intermittent use of the heater OFF-ON switch.

The forward clamp area of the adapter valve was not provided with a heater element. During the uninsulated valve test, the temperature of this area was approximately 275°F lower than the rest of the valve, and during the insulated valve test this area was approximately 250°F lower than the rest of the valve.

Temperature distribution is shown on figure 10.

Test Data

AMERICAN MACHINE
& FOUNDRY COMPANY

CALCULATION SHEET.

PAGE ____ OF ____

FOR CALCULATION SERIAL NO.

JOB ORDER NO.

CONTRACT NO.

TEMPERATURE (°F)

Figure 10. Temperature Distribution - External Heaters 72

PREPARED BY

A. J. BLATTER

CHECKED BY

DATE

3-28-62

DATE

CLASS	DIV.	NUMBER	MODEL
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DATE 3-28-62SHIFT 2NDSUPERVISOR A. BLATTER

OF

TECHNICIANS W. RAILAG. MEIERC. DELVECCHIO

THERMOCOUPLE NOS.

TEST TITLE HEATER ELEMENT TEST
VALVE UNINSULATEDN₂ PURGE PRESS. _____ TEST STARTED 8 PM

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	IN SECONDS	135	125	125	110	120	110	140	130	130	120	110	115	HEATERS ON 10 SEC OFF 10 SEC
2	160	140	125	140	110	135	110	150	130	130	125	130	120	" " "
3	"	150	130	160	115	150	115	160	130	135	125	130	120	" " "
4	"	155	135	175	115	160	115	155	135	140	125	135	120	HEATERS ON 20 SEC OFF 10 SEC
5	"	170	140	190	120	170	115	185	145	145	130	140	120	" " "
6	"	180	145	200	120	180	120	190	150	150	130	145	125	" " "
7	"	190	155	210	125	190	120	205	155	155	135	150	125	HEATERS ON 30 SEC OFF 10 SEC
8	"	200	160	220	130	200	125	220	165	160	135	155	130	" " "
9	"	210	165	225	135	200	130	225	175	170	140	165	135	" " "
10	"	220	175	235	140	205	135	235	180	175	145	170	140	" " "
11	"	225	180	235	145	215	140	240	190	185	150	180	145	" " "
12	"	240	190	245	150	225	145	255	200	190	160	195	150	HEATERS ON 40 SEC OFF 10 SEC
13	"	245	200	255	155	230	150	265	205	200	170	195	155	" " "
14	"	255	205	255	160	230	155	270	215	210	175	205	165	" " "
15	"	260	210	260	170	240	160	275	220	215	180	210	170	" " "
16	"	270	215	270	180	245	170	285	225	225	185	215	175	" " "
17	"	275	220	275	190	250	180	290	235	230	190	220	180	" " "
18	"	285	230	280	195	260	190	300	245	245	210	235	190	" " "
19	"	295	235	295	200	270	195	310	250	250	215	240	200	" " "
20	"	300	240	295	200	265	200	310	255	260	220	250	200	" " "
21	"	305	245	300	205	270	200	320	260	265	225	255	210	" " "

DATE 3-28-62

SHIFT 2ND

SUPERVISOR A. BLATTER

TECHNICIANS W. RAILA

C. MEIER

C. DELVECCHIO

TEST TITLE HEATER ELEMENT TEST

VALVE UNINSULATED

N₂ PURGE PRESS.

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	160 SEC.	310	250	300	200	275	200	320	270	270	235	260	215	HEATERS ON 40 SEC., OFF 10 SEC.
2	"	320	255	310	200	290	200	325	275	275	240	265	220	" " "
3	"	320	255	305	200	250	205	320	275	280	245	270	220	" " "
4	"	330	260	315	200	300	205	335	280	285	250	275	225	" " "
5	"	300	265	245	200	265	210	295	285	290	265	285	240	HEATERS OFF FOR 5 MIN.
6	"	310	265	270	200	275	210	315	280	295	270	285	245	HEATERS ON 50 SEC., OFF 10 SEC.
7	"	325	270	290	200	300	210	330	285	295	270	285	245	" " "
8	"	330	270	315	205	310	215	330	290	300	275	290	250	" " "
9	"	335	275	320	205	315	220	345	290	300	275	290	250	" " "
10	"	340	280	325	205	320	220	350	295	305	280	295	250	" " "
11	"	350	285	330	210	325	220	360	305	310	285	300	255	" " "
12	"	355	290	330	210	330	225	365	310	315	285	305	260	" " "
13	"	360	300	335	215	340	230	370	315	325	290	310	265	" " "
14	"	370	300	335	215	340	240	375	320	330	295	315	265	" " "
15	"	380	310	345	230	335	235	370	325	335	300	325	285	HEATERS OFF FOR 5 MIN.
16	240 SEC.	365	315	345	225	335	240	370	335	320	315	330	285	HEATERS ON 50 SEC., OFF 10 SEC.
17	"	370	320	350	230	340	250	380	340	345	315	335	290	" " "
18	"	380	325	355	230	345	250	380	345	350	320	320	295	" " "
19	"	385	330	355	235	350	245	395	350	350	330	345	300	HEATERS OFF FOR 5 MIN.
20	"	390	325	340	240	340	250	375	345	350	335	350	305	50 SEC. ON. - 10 SEC. OFF
21	"	385	325	360	240	345	255	385	345	355	340	350	305	" " "

DATE 3-28-62
SHIFT 2ND
SUPERVISOR T. MASON

TECHNICIANS G. MEIER
C. DELVECHIO

TEST TITLE HEATER ELEMENT TEST
VALVE UNINSULATED
N2 PURGE PRESS.

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	IN SECONDS	395	330	365	240	350	255	395	350	355	340	350	310	HEATERS ON 50 SEC. OFF 10 SEC.
2	320 SEC	400	340	365	245	355	260	400	355	370	345	355	310	" " "
3	"	405	345	370	250	360	265	410	360	370	350	360	315	" " "
4	"	405	350	365	255	360	270	410	370	375	355	360	220	HEATERS ON 50 SEC OFF 20 SEC.
5	"	405	350	360	255	360	270	410	370	375	360	365	325	" " "
6	"	405	355	365	255	365	275	405	375	380	360	370	325	" " "
7	"	405	355	370	260	370	275	405	375	380	365	370	330	HEATERS ON 50 SEC OFF 10 SEC.
8	"	410	360	375	260	365	280	410	380	385	365	375	335	" " "
9	"	410	360	380	265	375	280	400	380	385	370	375	335	" " "
10	"	415	365	365	265	380	285	415	385	390	375	380	340	HEATERS ON 60 SEC OFF 10 SEC.
11	"	420	370	380	270	385	290	415	385	395	375	380	340	" " "
12	"	425	375	385	270	385	290	425	390	400	380	385	345	" " "
13	"	425	375	390	275	390	290	420	390	400	380	390	350	" " "
14	"	425	380	390	275	390	295	425	395	400	385	390	350	HEATERS ON 70 SEC OFF 10 SEC.
15	"	430	380	395	275	390	295	425	400	405	395	395	355	" " "
16	"	430	385	395	280	395	300	430	400	405	390	395	355	HEATERS ON
17	"	435	385	395	280	400	300	435	400	405	395	400	360	" "
18	"	440	390	405	280	410	305	450	405	410	395	400	360	" "
19	"	450	395	410	285	410	305	450	415	415	400	410	365	" "
20	"	450	400	410	290	410	305	450	420	420	400	410	370	" "
21	"	450	400	410	290	410	305	450	420	420	400	410	370	" "

DATE 3-29-62
 SHIFT _____
 SUPERVISOR TO MASON

TECHNICIANS GT METER
C. DELVECHIO

TEST TITLE HEATER ELEMENT TEST
N2 PURGE PRESS.

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	320 SEC	220	180	200	155	205	155	220	185	205	200	205	190	50 ON 10 OFF
2	" "	260	195	240	165	240	165	270	200	215	200	215	190	" "
3	" "	255	220	225	180	215	185	255	225	235	210	235	200	AFTER 5 MIN. OFF 40 ON - 10 OFF
4	" "	290	230	255	190	265	190	305	240	250	220	245	210	" "
5	" "	275	245	230	200	255	200	275	250	255	235	255	225	AFTER 5 MIN. OFF 20 ON - 20 OFF
6	" "	295	250	250	205	270	210	305	260	265	240	260	230	" " "
7	" "	310	255	260	210	280	215	315	265	270	250	270	235	" " "
8	" "	220	265	270	215	290	220	330	275	280	255	275	240	" " "
9	" "	330	275	275	225	295	230	335	285	290	265	285	250	" " "
10	" "	335	285	280	230	300	235	345	290	290	270	290	255	" " "
11	" "	345	290	285	235	310	240	350	300	300	280	300	260	" " "
12	" "	355	300	290	240	315	245	360	310	310	290	310	270	" " "
13	" "	360	305	300	245	325	250	370	315	315	295	315	275	" " "
14	" "	370	315	305	250	330	260	375	325	325	305	325	285	" " "
15	" "	375	320	310	255	335	265	380	330	330	310	325	290	" " "
16	" "	380	325	315	260	340	270	385	340	335	315	335	295	" " "
17	" "	390	335	320	265	350	275	395	345	345	325	345	305	" " "
18	" "	395	340	325	275	350	280	400	350	350	330	350	310	" " "
19	" "	400	345	330	280	355	285	405	355	355	310	355	315	30 ON - 30 OFF
20	" "	405	350	335	280	360	290	410	360	360	345	360	320	" " "
21	" "	415	355	345	285	370	295	425	370	365	350	360	330	" " "

DATE 3-29-62
 SHIFT _____
 SUPERVISOR T. MASON

TECHNICIANS G. MEYER
C. DELVECCHIO

TEST TITLE HEATER ELEMENT TEST
 N₂ PURGE PRESS. _____

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	320Sec	425	365	350	290	375	300	435	375	375	355	370	335	30 ON - 30 OFF
2	"	430	370	355	300	380	305	435	380	380	360	375	340	" " "
3	"	435	375	355	300	385	310	440	390	385	370	380	350	" " "
4	"	435	375	355	305	385	315	435	390	390	375	385	350	" " "
5	"	445	380	360	310	390	320	445	395	395	380	390	355	" " "
6	"	445	385	365	315	395	325	450	400	395	385	395	360	" " "
7	"	450	390	365	315	400	330	450	400	400	390	395	365	" " "
8	"	450	390	370	320	400	330	455	405	400	390	400	370	" " "
9	"	460	400	375	325	405	340	465	410	405	395	400	370	30 ON - 20 OFF
10	"	470	405	385	330	415	340	475	415	415	400	415	375	" " "
11	"	475	410	390	335	425	350	485	425	415	405	415	380	30 ON - 30 OFF
12	"	475	415	385	340	425	355	480	430	425	410	420	385	" " "
13	"	480	420	390	345	425	360	485	430	425	415	425	390	" " "
14	"	480	425	390	350	430	365	485	435	425	420	425	395	" " "
15	"	490	440	400	350	435	365	495	435	435	420	430	400	40 ON - 30 OFF
16	"	495	430	405	355	440	370	500	445	440	425	440	405	" " "
17	"	500	435	410	360	445	370	505	450	440	430	440	405	" " "
18	"	500	440	410	365	445	380	510	455	450	435	445	410	" " "
19	"	505	445	415	365	450	375	510	460	450	440	450	415	30 ON - 30 OFF
20	"	505	445	410	370	450	380	505	460	450	440	445	415	" " "
21	"	505	445	410	370	450	385	510	460	450	445	450	420	40 ON - 30 OFF

DATE 3-29-62

SHIFT _____

SUPERVISOR T. MASONTECHNICIANS G. MEIERC. DELVECCHIOTEST TITLE HEATER ELEMENT TESTN₂ PURGE PRESS. _____

TEMP IN °F

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	320 SEC	515	450	425	370	460	385	520	465	455	450	455	425	HEATERS ON 40 SEC OFF 30 SEC
2	"	520	455	425	375	460	390	525	470	460	455	460	425	" "
3	"	520	460	425	380	460	390	520	475	460	455	460	430	HEATERS ON 30 SEC OFF 30 SEC
4	"	525	460	430	380	465	395	530	475	465	460	465	430	" "
5	"	525	465	430	385	465	395	525	480	465	460	465	435	" "
6	"	525	465	430	385	465	400	520	480	470	465	465	440	" "
7	"	535	465	435	385	465	400	525	480	470	465	475	440	HEATERS ON 40 SEC OFF 30 SEC
8	"	530	470	450	390	470	405	540	485	475	460	470	440	" "
9	"	530	470	440	390	475	405	530	485	475	470	470	440	HEATERS ON 30 SEC OFF 30 SEC
10	"	530	470	440	390	470	405	525	485	475	470	470	445	" "
11	"	535	470	440	390	470	405	530	485	475	470	470	445	HEATERS ON 40 SEC OFF 30 SEC
12	"	540	470	445	395	475	405	530	485	475	475	475	445	" "
13	"	545	475	450	395	475	410	540	490	480	475	475	445	" "
14	"	545	480	455	405	480	415	545	490	480	475	480	450	" "
15	"	550	485	455	410	480	420	545	495	480	475	485	455	HEATERS ON 30 SEC OFF 30 SEC
16	"	570	485	460	410	485	425	550	500	485	480	485	455	" "
17	"	565	490	480	415	495	425	565	505	490	490	490	460	" "
18	"	565	500	475	420	500	430	565	510	490	490	495	460	" "
19	"	570	500	470	425	500	435	560	515	495	490	500	465	" "
20	"	570	510	475	430	505	440	565	520	505	500	500	475	" "
21	"	570	510	480	435	505	445	565	520	505	500	500	475	HEATERS ON 30 SEC OFF 20 SEC

DATE 3-29-63
 SHIFT _____
 SUPERVISOR J. EDSON

TECHNICIANS W. RAILA

TEST TITLE HEATER ELEMENT
TEST
 N₂ PURGE PRESS. _____

Test No.	Time of Test	#4	#10	#5	#12	#6	#13	#7	#11	#14	#8	#15	#9	REMARKS
1	320 SEC	570	510	475	435	505	445	565	520	505	505	500	480	HEATER 30 SEC. ON 20 SEC. OFF
2	"	570	510	480	435	505	445	570	520	500	500	500	475	30 SEC ON - 10 SEC OFF
3	"	575	510	485	435	510	445	575	520	505	500	500	475	" "
4	"	580	515	500	440	515	450	585	525	510	505	505	475	" "
5	"	590	525	515	445	525	455	590	535	515	510	510	480	30 SEC ON - 30 SEC OFF
6	"	595	535	505	450	530	470	595	545	525	510	520	495	" "
7	"	590	530	500	455	530	465	590	545	520	520	520	490	" "
8	"	600	540	520	460	540	470	595	550	525	520	525	495	" "
9	"	605	545	530	465	545	470	605	550	525	525	525	495	30 SEC ON 10 SEC OFF
10	"	610	550	530	470	545	475	610	555	530	530	530	500	" "
11	"	610	550	535	470	550	475	615	555	530	530	530	500	" "
12														
13														TEST ENDED
14														10:30 A.M.
15														
16														
17														
18														
19														
20														
21														

DATE 3-28, 29-60

SHIFT _____

SUPERVISOR T. MASON, A. BLATTERTECHNICIANS W. RAILA - G. MEIERS. NOTOC. DELVECCHIOTEST TITLE HEATER ELEMENT TESTN₂ PURGE PRESS.

Test No.	Time of Test	SURFACE OF GRAY LOC CLAMP	SURFACE OF FORWARD CLAMP	FORWARD GRAY LOC HUB	VALVE BORE AT FWD CLAMP	INSIDE TEST CHAMBER	SURFACE OF TEST CHAMBER	VALVE INSULATED	REMARKS
1		380°F	105°F	155°F	200°F	225°F	150°F	NO	READINGS OBTAINED USING SURFACE PYROMETER.
2		390°F	107°F	158°F	204°F	230°F	155°F	NO	READINGS TAKEN AT CONCLUSION OF UNINSULATED HEATER ELEMENT TEST WHEN MAX. TEMP ON VALVE BODY OF 450°F WAS REACHED ON VALVE BODY
3									
4									
5									
6									
7		505°F	390°F	425°F	325°F	315°F	200°F	TOTALLY INSULATED	READINGS OBTAINED USING A THERMOCOUPLE.
8		580°F	395°F	425°F	328°F	315°F	205°F	"	READINGS TAKEN AT CONCLUSION OF INSULATED HEATER ELEMENT TEST WHEN MAX. TEMP. OF 610°F WAS REACHED ON VALVE BODY
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

DATE 3-29-61
 SHIFT DAY
 SUPERVISOR A. BLATTER

TECHNICIANS W. RAILA
G. DELVECCHIO

TEST TITLE _____
 N₂ PURGE PRESS. _____

Test No.	Time of Test	4	10	5	12	6	13	7	11	14	8	15	9	REMARKS
1	EVERY 5 MIN	580	540	480	460	530	470	560	555	530	530	530	510	
2	"	545	515	450	440	500	450	520	525	515	530	510	500	
3	"	512	490	427	420	478	438	492	500	490	513	490	485	
4	"	490	470	413	400	460	415	470	480	470	495	470	470	
5	"	465	450	400	385	440	400	450	460	450	480	450	450	
6	"	440	435	380	365	420	380	425	435	430	455	430	430	
7	"	415	400	370	342	400	355	395	415	415	435	410	410	
8	"	395	385	355	328	385	340	375	385	400	415	395	372	REMOVED ONE END OF INSUL.
9	"	370	360	335	310	365	320	355	375	375	390	375	372	" " " " "
10	"	350	340	320	295	345	305	330	355	360	375	355	355	REMOVE OTHER END OF INSUL.
11	"	305	325	295	280	325	290	300	335	335	355	335	335	ALL INSULATION ALL OFF
12	EVERY 10 MIN	270	300	285	260	300	265	275	310	308	330	312	310	
13		243	265	255	235	270	240	250	278	278	295	282	275	
14		220	240	235	220	245	220	225	250	250	265	260	250	
15														
16														
17														
18														
19														
20														
21														

INVESTIGATION OF WEDGE AND STEM SEAL FAILUREWedge Failure

Since several components of the external ball-actuating mechanism were damaged during cyclic testing, the adapter valve was disassembled and inspected. The wedge was found damaged. The top section of the wedge, where it was coupled to the wedge shaft, had been fractured thus allowing separation of the wedge and wedge shaft. (See figure 8.) This occurred with the wedge in the engaged position. On attempting to open the ball with the pneumatic motor, the locked wedge held the ball in the closed position. The motor torque was transmitted to the various driven components of the ball-actuating mechanism, causing damage to these parts. The damaged wedge was repaired by grinding a dovetail slot, 1.4 inch by 1.84 inch, with a 20-degree taper in the damaged area. An insert machined to fit the dovetail slot was designed and fabricated to secure the wedge shaft to the wedge (see figure 11).

Stem-Seal Shaft Bushing and Second Wedge Failure

Testing continued with the reworked wedge and repaired actuator components installed on the valve. Immediately after the heater element tests, both the ball- and wedge-actuating shafts experienced binding during rotation. The adapter valve was again disassembled and the stem seals inspected. Belleville-spring-type sealing surfaces of the gasket deflector ring and the dynamic gasket had collapsed on both the ball-stem seal and the wedge-stem seal. The ball shaft was scored in the area in contact with the stem seal. The wedge shaft was in good condition. The graphite bushings on both the wedge and ball shafts were cracked. The ID of the ball shaft bushing was elongated, apparently due to the high radial loads on the ball shaft as the wedge descends during the ball closing operation.

During this disassembly, the reworked wedge-to-wedge shaft area of attachment was also found damaged. The wedge-elevating block replacement

Figure 11. Modified Wedge-to-Wedge Shaft Attachment

(figure 12) was cracked through its narrowest section. The reworked wedge also showed a hairline crack (figure 13) starting at the 3/4 inch through-hole across the top of the wedge to the tapered side of the wedge.

A review of the wedge redesign indicated that the assumptions relative to the effect of stress concentration, shock, and the coefficient of friction of the actuator drive system had been underestimated as to the resultant torques transmitted to the wedge shaft and wedge.

Component Investigation

It was determined that a more detailed investigation of the stem-seal and wedge failure was essential to properly evaluate and correct the cause of failure. Four tests to obtain definitive information were required to continue the investigation. The tests conducted were:

- a. Determine and record the ID of the graphite bushing before installation, immediately after installation, 24 hours after installation, and at 600°F. This bushing was pressed into the ball-shaft cap for this test.
- b. Determine concentricity of the bores in the ball-stem cap and the wedge-stem cap without the graphite bushings installed in the holes.
- c. Determine if the wedge has been striking the top of the valve bore during wedge retraction.
- d. Without a wedge force on the ball, determine the hydraulic pressure required to seal the ball valve against gross leakage.

The ID dimensions of the graphite bushing before and after installation are listed below. These dimensions were recorded at two points on the bushing ID. One point is referred to as A-A and the second point, which is 90 degrees from A-A, is referred to as B-B.

Bushing ID Before Installation (as built) 0.762 in. (typical)

Bushing ID (in inches) Immediately After Installation
(using a typical bushing)

	A-A			
Top	0.7595	0.7589	0.7602	0.7598
Bottom	0.7550	0.7555	0.7554	0.7557

Figure 12. Second Wedge Failure

Figure 13. Wedge Damage Contributing to Second Failure

B-B

Top	0.7590	0.7592	0.7590	0.7591
Bottom	0.7555	0.7550	0.7552	0.7551

Bushing ID (in inches) 24 Hours After Installation

A-A

Top	0.7601	0.7600	0.7594	0.7598
Bottom	0.7563	0.7564	0.7567	0.7564

B-B

Top	0.7580	0.7583	0.7579	0.7579
Bottom	0.7553	0.7553	0.7553	0.7555

Bushing ID (in inches) at High Temperature (580°F to 620°F)

A-A

Top	0.7625	0.7625	0.7627	0.7622
Bottom	0.7586	0.7592	0.7588	0.7587

B-B

Top	0.7605	0.7605	0.7602	0.7606
Bottom	0.7587	0.7586	0.7588	0.7586

The bore in the ball-stem cap (figure 14) and the wedge-stem cap (figure 15) were checked for concentricity. The bushing bore in the ball-stem cap was found to be concentric; however, the hole had a 0.001-inch taper from top to bottom. The bushing hole in the wedge-stem cap was found to be concentric to within 0.009 inch. (See attached sketches for actual measurements.)

The wedge was retracted manually, and it was found that if it were not stopped in time, the wedge would strike the top of the housing bore. The top of the bore around the wedge-shaft aperture showed evidence of the wedge having contacted this area. The outline of the wedge was slightly indented into the top of the valve housing (approximately 0.001 to 0.002 inch).

The valve design provides only for a limit-switch-operated solenoid valve to stop the pneumatic motor when the wedge is being retracted. This remote-control feature had not been installed during this test period.

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO.

CONCENTRICITY CHECK OF BUSHING HOLE

JOB ORDER NO.

CONTRACT NO.

B-B DIMENSIONS

TOP - 1.1245

MIDDLE - 1.1248

BOTTOM - 1.1235

BALL STEM CAP 5011-3

ADAPTER VALVE

Figure 14. Concentricity Check of Bushing Bore

88

PREPARED BY

W.N. MENNONNA

DATE

4-16-62

CHECKED BY

DATE

CLASS

DIV.

NUMBER

MODEL

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO.

JOB ORDER NO.

CONTRACT NO.

CONCENTRICITY CHECK OF BUSHING HOLE

B-B. DIMENSIONS

TOP - 1.3768

MIDDLE - 1.3760

BOTTOM - 1.3760

WEDGE STEM CAP 5011-2

ADAPTER VALVE

Figure 15. Concentricity Check of Bushing Bore

89

PREPARED BY

W.N. MENNONA

DATE

4-16-62

CHECKED BY

DATE

CLASS

DIV.

NUMBER

MODEL

The pneumatic motor on the ball- and wedge-actuating mechanism was controlled by manual operation of a four-way valve during the tests in which the wedge failed. Thus, without an automatic motor-cutout, it was conceivable that the wedge might strike the housing.

A test to determine the necessity of a wedge was performed. The hydraulic pressure required to seal the ball valve against gross leakage was determined.

A simulated ball shaft was machined and used to hold the ball in the closed position against the graphite seat. The only force exerted to seat the ball against the graphite seat was the hydraulic test pressure. See figure 16 for test setup.

Prior to this test, the ball was coated with bluing and then placed in its graphite seat. In this manner, a close approximation of the valve seating area at ambient conditions was determined. Figure 17 shows the valve seating area.

The first series of tests was conducted with the bluing still on the valve seat and ball. This was done in an attempt to determine the valve seating area at high pressures. At the conclusion of the test, the graphite seat was inspected; however, the seating area could not be accurately distinguished as the water leakage had disturbed and smeared the bluing pattern.

During this test, the leakage past the ball ranged from a high of 2100 cc per hour, at ambient pressure, to a low of 15 cc per hour from 400 to 750 psig.

This leakage test was repeated three additional times without the bluing on the ball or valve seat. The leakage past the ball ranged from a high of 4600 cc per hour at 50 psig, to approximately 50 cc per hour at from 600 to 1500 psig (see the attached graph and data sheets for the test results).

Conclusion

Although graphite-bushing material has been applied satisfactorily in similar environments, manufacturing and assembly tolerances, and thermal characteristics required for adapter valve application result in excessive

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO. _____

JOB ORDER NO. _____

CONTRACT NO. _____

Figure 16. Ball Seal Leak Test and Setup - Less Wedge Force

91

PREPARED BY

W. MENNONNA

DATE

4-14-62

CHECKED BY

TEST SETUP OF BALL SEAL LEAK TESTS

DATE

TEST SETUP OF WILCOX ROBEK ON BALL

CLASS

DIV.

NUMBER

MODEL

FOR CALCULATION SERIAL NO.

JOB ORDER NO.

CONTRACT NO.

ADAPTER VALVE GRAPHITE SEAT

1. BALL VALVE COATED WITH BLUEING AND PLACED IN GRAPHITE SEAT. THE ONLY FORCE ON THE SEAT WAS THE WEIGHT OF THE BALL.

Figure 17. - Adapter Valve Graphite Seat

92

PREPARED BY

W. N. MENNONNA

DATE

4-16-62

CHECKED BY

DATE

CLASS

DIV.

NUMBER

MODEL

shaft-bushing clearance. This clearance enables radial shaft movement which in turn contributed greatly toward shaft-seal failure.

There is a total clearance of 0.004 to 0.006 inch existing between the actuating shaft OD and the bushing ID under both ambient and high temperature (600°F) condition. Since there was a shaft OD expansion of 0.003 inch at high temperature, this condition also existed at operating temperatures. See figure 18.

The wedge retraction cycle must be stopped in time to prevent the wedge from striking the top of the valve housing and causing damage to the wedge.

The oval shape of the graphite bushings (see figures 19 and 20) used during the adapter valve testing was probably caused by wear due to radial shaft loads. Bushing mounting holes in the ball-stem cap and the wedge-stem cap were found to be concentric and did not contribute to the failures.

A preload, equivalent to 200 psig hydraulic pressure, is required to seal the ball valve to the maximum acceptable leakage rate of 300 cc per hour.

At hydraulic pressures above 200 psig, the sealing force was sufficient to permit leakage at a rate of 50 cc per hour. This rate was obtained within a pressure range of 600 to 1500 psig. Leakage during pressure increase to minimum pressure would also contribute to the total leakage, but the total would be a function of the elapsed time.

As a result of this investigation it was decided to design, manufacture and install shaft bushings with an accurately controlled ID to provide better actuating shaft support and thus eliminate excessive radial loads being transmitted to the stem seals. A search was initiated for other high-temperature bushing materials with higher strength and also less subject to deterioration from wear than the original graphite bushings. Steps were completed to repair the stem seals and also to manufacture a new wedge with an improved method of wedge-to-wedge shaft attachment.

The machining, hardening, and lapping of the replacement wedge (figure 21) was completed. The new shaft bushings (figure 22) made of Waukesha Company metal No. 54WM were machined, assembled, and line reamed. The installed and finished ID dimension of the upper and lower ball-shaft bushings,

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO.
GRAPHITE BUSHING AND SHAFT
EXPANSION AT 600°F

JOB ORDER No.

CONTRACT No.

BUSHING

SHAFT

BUSHING (TOP)
AMB. TEMP. 600°F
A-A .7598 A-A .7625
B-B .7581 B-B .7604

SHAFT (BUSHING)
AMB TEMP 600°F
A-A .7510 A-A .7540
B-B .7510 B-B .7540

BUSHING (BOTTOM)
AMB. TEMP. 600°F
A-A .7564 A-A .7588
B-B .7553 B-B .7587

Figure 18. Graphite Bushing and Shaft Expansion at 600°F

94

PREPARED BY

W. N. MENNONNA

DATE

4-20-62

CHECKED BY

DATE

CLASS

DIV.

NUMBER

MODEL

BALL SHAFT CAP BUSHING

BALL SHAFT BODY BUSHING

Figure 19. Ball Shaft Bushing Wear

MAT. GRAPHITE		SIZE OR PATT. NO.		DRAWN BY J. M. EDSON		DATE 2-5-62
DESCR. BALL SHAFT BUSHING WEAR		CLASS	DIV.	NUMBER	MODEL	REV.

VIEW A-A

VIEW B-B

WEDGE SHAFT CAP BUSHING

VIEW A-A

VIEW B-B

WEDGE SHAFT BODY BUSHING

Figure 20. Wedge Shaft Bushing Wear

96

MAT. GRAPHITE	SIZE OR PATT. NO.	DRAWN BY J. EDSON	DATE 7-5-62	Amf TRADE MARK
DESCR. WEDGE SHAFT BUSHING WEAR	CLASS 89	DIV. 58	MODEL REV.

Figure 21. Wedge-to-Wedge Shaft Attachment,
Second Modification

Figure 22. Waukesha Metal Bushings

and the lower wedge-shaft bushing was 0.7520 inch. The finished ID dimension of the upper wedge-shaft bushing was 1.005 inch. Clearance was held to ± 0.0005 inch in the ambient condition.

With the new bushings pressed into the adapter valve housing and stem caps, the assembly was cleaned and remounted in the test stand. The stem seals were pressed into the housing and the assembly of the ball and wedge was completed. The valve was assembled with tightening torques of 50 foot-pounds on the forward clamp, 100 foot-pounds on the 4-inch pipe clamp, and 200 foot-pounds on the 6-inch pipe clamp.

Test Data

DATE 4-16-62
 SHIFT DAY
 SUPERVISOR J. EDSON
W. MENNONNA

TECHNICIANS G. MEIER

TEST TITLE DETERMINATION OF HYDRAULIC
PRESS. REQ'D TO SEAT BALL
N₂ PURGE PRESS.

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE CC/HR	TEST PRESS.	TEST TEMP.				REMARKS
1		BALL SEAL	1715	AMB.	AMB.				NO WEDGE FORCE IN BALL DURING THIS TEST.
2		"	4600	50	"				THE ONLY FORCE APPLIED TO SEAT THE BALL WAS THE HYDRAULIC PRESSURE
3		"	3090	100	"				
4		"	960	150	"				
5		"	290	200	"				
6		"	140	250	"				
7		"	100	350	"				
8		"	72	400	"				
9		"	60	500	"				
10		"	58	600	"				
11		"	50	700	"				
12		"	50	1000	"				
13		"	52	700	"				
14		"	56	500	"				
15		"	56	350	"				
16		"	62	250	"				
17		"	60	200	"				
18		"	66	150	"				
19		"	80	100	"				
20		"	2450	50	"				
21		"	700	AMB	"				

DATE 4-16-62
 SHIFT DAY
 SUPERVISOR J. EDSON

TECHNICIANS C. MEIER

TEST TITLE DETERMINATION OF HYDRAULIC
 PRESSURE REQ'D TO SEAT BALL
N2 PURGE PRESS.

W. MENNON NA

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE CC/HR	TEST PRESS	TEST TEMP				REMARKS
1		BALL SEAL	1800	AMB.	AMB.				NO WEDGE FORCE ON BALL DURING THIS TEST.
2		"	3200	100	"				THE ONLY FORCE APPLIED TO SEAT THE BALL WAS THE HYDRAULIC PRESSURE.
3		"	1000	150	"				
4		"	275	200	"				
5		"	155	250	"				
6		"	88	350	"				
7		"	76	400	"				
8		"	65	500	"				
9		"	55	600	"				
10		"	52	700	"				
11		"	50	1000	"				
12		"	50	1250	"				
13		"	50	1500	"				
14		"	52	1000	"				
15		"	55	700	"				
16		"	62	400	"				
17		"	60	250	"				
18		"	68	150	"				
19		"	96	100	"				
20		"	2600	50	"				
21		"	730	AMB.	"				

DATE 4-16-62TECHNICIANS CT. MEIERTEST TITLE DETERMINATION OF HYDRAULIC
PRESSURE REQ'D TO SEAT BALL
N₂ PURGE PRESS. _____SHIFT DAYSUPERVISOR W. MENNANNA

Test No.	Time of Test	SEAL UNDER TEST	LEAKAGE CC/HR.	TEST PRESS.	TEST TEMP				REMARKS
1		BALL SEAL	1750	AMB.	AMB				
2		"	4500	50	"				
3		"	3000	100	"				
4		"	1095	150	"				
5		"	240	200	"				
6		"	165	250	"				
7		"	90	350	"				
8		"	74	400	"				
9		"	62	500	"				
10		"	56	600	"				
11		"	52	700	"				
12		"	52	1000	"				
13		"	54	1250	"				
14		"	52	1500	"				
15		"	50	1000	"				
16		"	50	700	"				
17		"	68	400	"				
18		"	60	250	"				
19		"	60	150	"				
20		"	2200	50	"				
21		"	660	AMB.	"				

FUEL-STOP TESTSTest Equipment and Instrumentation

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
1. CO ₂ cylinder	AIRCO	Provide actuating gas to fuel stop piston.
2. CO ₂ pressure regulator	MATHESON CO.	Vary actuating gas pressure to fuel-stop piston.
3. N ₂ Cylinder	AIRCO	Provide pressurizing gas to adapter valve.
4. N ₂ pressure regulator	AIRCO	Vary pressurizing gas to adapter valve.
5. Dial indicator	BROWN & SHARPE	Used to determine length of stroke of fuel-stop shaft.

Test Setup

The fuel-stop was tested while mounted in the adapter valve. CO₂ gas was piped to the fuel-stop piston to provide the required actuating force. The adapter valve was filled with water at ambient temperature and nitrogen cover gas. The tightening torque on the fuel-stop-shaft seal, a silicone O-ring, was set at 40 inch-pounds. A dial indicator was mounted at the bottom of the fuel-stop shaft and was used to determine the shaft stroke.

Test Procedure

The tests were conducted under ambient-temperature, high-pressure conditions. Using nitrogen gas as the pressurizing medium, the internal adapter valve pressure was increased to 1500 psig. This pressure was then decreased to zero psig in increments of 250 psig. At each pressure increment, the CO₂ pressure required to open the fuel-stop was determined.

Test Discussion

The test results indicate that a CO₂ pressure of 140 psig is required to open the fuel-stop when the internal pressure of the adapter valve is 1500 psig. The CO₂ pressure required drops to a low of 12 psig when the internal adapter valve pressure was zero psig.

Throughout the test there was no visible leakage from the fuel-stop-shaft seal.

During the test, a dial indicator mounted at the bottom of the fuel-stop shaft indicated the shaft stroke to be 0.260 inch.

Due to the absence of a completed CO₂ manifold and control assembly during this test, the remaining fuel-stop tests have been postponed until the testing of the refueling machine head assembly.

Test Data

DATE 5-17-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE FUEL STOP TEST
(BASE LINE DATA)N₂ PURGE PRESS. _____

Test No.	Time of Test	TEST TEMP.	ADAPTER VALVE PRESS.	CO ₂ PRESS TO OPEN FUEL STOP	TORQUE ON SHAFT SEAL	VISIBLE SHAFT LEAKAGE	FUEL STOP SHAFT STROKE	REMARKS
1		AMB	1500	140	40 N.L.B.	NONE	.260"	SILICON "O" RINGS USED AS SEALS ON FUEL STOP PISTON AND SHAFT.
2		"	1500	140	"	"	"	
3		"	1250	118	"	"	"	
4		"	1250	118	"	"	"	
5		"	1000	96	"	"	"	
6		"	1000	96	"	"	"	
7		"	750	74	"	"	"	
8		"	750	74	"	"	"	
9		"	500	55	"	"	"	
10		"	500	55	"	"	"	
11		"	250	35	"	"	"	
12		"	250	35	"	"	"	
13		"	0	12	"	"	"	
14		"	0	12	"	"	"	
15								
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REWORKED-STEM-SEAL LEAKAGE TESTSTest Equipment and Instrumentation

No new test equipment or instrumentation was required for leak testing of the rebuilt stem seals.

Test Setup

The stem seals (figure 23) were installed in the adapter valve with their original relationship. One seal was installed on the ball-actuating shaft and the other on the wedge-actuating shaft. The adjusting nut of each seal was tightened until a torque of 150 inch-pounds was reached. At this torque, the shafts could no longer be manually rotated. The adapter valve was filled with water at ambient temperature, and the valve was pressurized using nitrogen gas. Leakage from the stem seals was observed visually.

Test Procedure

Static leak testing of the stem seals was accomplished with the adapter valve full of water at ambient temperature and with nitrogen gas as the pressurizing medium. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi, and from 1250 psi to 1500 psi in increments of 50 psi. Each increment of pressure was maintained for 5 minutes and stem-seal leakage was observed visually. As leakage was observed, the torque on the seal adjusting nut was increased until the leakage stopped. The test was then repeated starting at the pressure increment at which the leakage was observed.

Dynamic leak testing of ball-stem seal was accomplished with the adapter valve full of water at ambient temperature and nitrogen cover gas. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi, and from 1250 psi to 1500 psi in increments of 50 psi. At each increment of

Figure 23. Stem Seals and Stem

pressure, the ball (with the Geneva mechanism disengaged and the wedge retracted) was rotated through ten opening and closing cycles. The torque required for each rotation was recorded and leakage was visually checked.

Dynamic leak test of wedge-stem seal was accomplished with the adapter valve full of water at ambient temperature and pressurized with nitrogen cover gas. The valve was pressurized from atmospheric pressure to 1250 psi in increments of 250 psi, and from 1250 psi to 1500 psi in increments of 50 psi. At each increment of pressure, the wedge (with the Geneva mechanism disengaged and the ball open) was cycled ten times through its lock-and-unlock cycle. The breakaway torque required for each cycle was recorded and leakage was visually checked.

Test Discussion

The tightening torque applied to the adjusting nut of each stem seal was set during the static leak testing of the seals. This torque was initially determined to be 240 inch-pounds for each seal. The seals were successfully leak tested using this tightening torque; however, leakage soon developed as the test program continued.

Increasing the torque on the adjusting nut of the seals did not decrease the leakage. This leakage was approximately 5 cc per minute. The seal manufacturer recommended a 0.004-inch shim be placed between the dynamic gasket and the gasket backup sleeve. This shim permitted greater deflection of the sealing lip of the dynamic gasket and thus improved the sealing properties of the seals. A static leak test indicated that tightening torques of 280 inch-pounds on the ball-stem seal and 350 inch-pounds on the wedge-stem seal were required to produce a satisfactory static-sealing condition.

The dynamic leak tests of the stem seals continued. The breakaway torque for each cycle was recorded and leakage at each pressure increment was visually checked. The torque on the wedge-stem seal was maintained at 350 inch-pounds throughout the test. There was no leakage observed during this test and the required wedge-shaft breakaway torque was a maximum of

18 foot-pounds at 1500 psig internal pressure. The shaft breakaway torque was determined by adapting a torque wrench directly to the top of the wedge shaft.

The torque on the ball-stem seal was maintained at 280 inch-pounds throughout the test. There was no leakage observed during this test and the required ball-shaft breakaway torque was a maximum of 21 foot-pounds at 1500 psig internal pressure. The shaft breakaway torque was determined by adapting a torque wrench directly to the top of the ball shaft.

A static leak test of the stem seals was then conducted under operating-temperature and operating-pressure conditions. Hot water was circulated through the adapter valve. The temperature of the adapter valve was increased at a rate not exceeding 20°F per minute, and a temperature difference no greater than 50°F was maintained between the internal and external surfaces of the valve. The adapter valve external body heaters were utilized to maintain the external body temperature to within 50°F of the internal body temperature. During this test, the maximum conditions reached were 1500 psi at 525°F. No leakage was observed from either stem seal throughout this test.

Test Data

DATE 5-26-62SHIFT DAYSUPERVISOR W. MENNONNA

TECHNICIANS _____

TEST TITLE INITIAL LEAK TEST OF
REWORKED STEM SEALS (STATIC)N₂ PURGE PRESS. _____ PAGE 1 of 1

Test No.	Time of Test	ADAPTER VALVE PRESS	TORQUE ON WEDGE STEM SEAL	TORQUE ON BALL STEM SEAL	TEST TEMP.	VISIBLE LEAKAGE WEDGE STEM SEAL	VISIBLE LEAKAGE BALL STEM SEAL	REMARKS
1	5 MIN	0	20 FT. LB.	20 FT. LB.	AMB.	NONE	NONE	① THE REWORKED STEM SEALS NOW HAVE A SOLID BELLEVILLE WASHER.
2	"	250	"	"	"	"	"	
3	"	500	"	"	"	"	"	② NEITHER STEM SEAL
4	"	750	"	"	"	"	"	SHOWED ANY EVIDENCE
5	"	1000	"	"	"	"	"	OF LEAKAGE THROUGH
6	"	1250	"	"	"	"	"	THIS TEST.
7	"	1300	"	"	"	"	"	
8	"	1350	"	"	"	"	"	
9	"	1400	"	"	"	"	"	
10	"	1450	"	"	"	"	"	
11	30 MIN	1500	"	"	"	"	"	
12	5 MIN	1400	"	"	"	"	"	
13	"	1300	"	"	"	"	"	
14	"	1200	"	"	"	"	"	
15	"	1100	"	"	"	"	"	
16	"	1000	"	"	"	"	"	
17	"	750	"	"	"	"	"	
18	"	500	"	"	"	"	"	
19	"	250	"	"	"	"	"	
20	"	0	"	"	"	"	"	
21								

DATE 5-26-62

TECHNICIANS _____

TEST TITLE LEAK TEST OF REWORKED
STEM SEALS (STATIC)SHIFT DAYSUPERVISOR W. MENNONNAN₂ PURGE PRESS. _____ Page 2 of 2

Test No.	Time of Test	ADAPTER VALVE PRESS.	TORQUE ON WEDGE STEM SEAL	TORQUE ON BALL STEM SEAL	TEST TEMP.	VISIBLE LEAKAGE WEDGE STEM SEAL	VISIBLE LEAKAGE BALL STEM SEAL	REMARKS
1	5 MIN	0	20 FT. LB	20 FT. LB	AMB.	NONE	NONE	NEITHER STEM SEAL SHOWED ANY EVIDENCE OF LEAKAGE THROUGHOUT THIS TEST
2	"	250	"	"	"	"	"	
3	"	500	"	"	"	"	"	
4	"	750	"	"	"	"	"	
5	"	1000	"	"	"	"	"	
6	"	1250	"	"	"	"	"	
7	"	1300	"	"	"	"	"	
8	"	1350	"	"	"	"	"	
9	"	1400	"	"	"	"	"	
10	"	1450	"	"	"	"	"	
11	10 MIN	1500	"	"	"	"	"	
12	5 MIN	1450	"	"	"	"	"	
13	"	1400	"	"	"	"	"	
14	"	1350	"	"	"	"	"	
15	"	1300	"	"	"	"	"	
16	"	1250	"	"	"	"	"	
17	"	1000	"	"	"	"	"	
18	"	750	"	"	"	"	"	
19	"	500	"	"	"	"	"	
20	"	250	"	"	"	"	"	
21	"	0	"	"	"	"	"	

DATE 5-26-62SHIFT DAYSUPERVISOR W. MENNONNA

TECHNICIANS _____

TEST TITLE LEAK TEST OF REWORKEDSTEM SEALS (STATIC)N₂ PURGE PRESS. _____

Page 3 of 3

Test No.	Time of Test	WINTER VALVE PRESS.	TORQUE ON WEDGE STEM SEAL	TORQUE ON BALL STEM SEAL	TEST TEMP.	VISIBLE LEAKAGE, WEDGE STEM SEAL	VISIBLE LEAKAGE, BALL STEM SEAL	REMARKS
1	5 MIN	0	20 FT. LB	20 FT. LB	AMB.	NONE	NONE	NEITHER STEM SEAL SHOWED ANY EVIDENCE OF LEAKAGE THROUGHOUT THIS TEST.
2	"	250	"	"	"	"	"	
3	"	500	"	"	"	"	"	
4	"	750	"	"	"	"	"	
5	"	1000	"	"	"	"	"	
6	"	1250	"	"	"	"	"	
7	"	1300	"	"	"	"	"	
8	"	1350	"	"	"	"	"	
9	"	1400	"	"	"	"	"	
10	"	1450	"	"	"	"	"	
11	10 MIN	1500	"	"	"	"	"	
12	5 MIN	1450	"	"	"	"	"	
13	"	1400	"	"	"	"	"	
14	"	1350	"	"	"	"	"	
15	"	1300	"	"	"	"	"	
16	"	1250	"	"	"	"	"	
17	"	1000	"	"	"	"	"	
18	"	750	"	"	"	"	"	
19	"	500	"	"	"	"	"	
20	"	250	"	"	"	"	"	
21	"	0	"	"	"	"	"	

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEALN₂ PURGE PRESS. _____ PAGE 1 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL BREAK-AWAY TORQUE CW ROTATION	BALL BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		AMB.	30 IN. LB.	35 IN. LB.	NONE	280 IN. LB.	AMB.	A .004 INCH SHIM HAS BEEN PLACED BETWEEN THE GASKET BACKUP SLEEVE (54-105) AND THE DYNAMIC GASKET (68-432) OF THIS STEM SEAL
2		AMB.	"	"	"	"	"	
3		AMB.	"	"	"	"	"	
4		AMB.	"	"	"	"	"	DURING THIS TEST THE BALL SHAFT WAS ROTATED 90° IN THE CLOCKWISE DIRECTION
5		AMB.	"	"	"	"	"	AND THEN 90° IN THE COUNTERCLOCKWISE DIRECTION
6		AMB.	"	"	"	"	"	
7		AMB.	"	"	"	"	"	BALL & WEDGE NOT IN VALVE DURING THIS TEST.
8		AMB.	"	"	"	"	"	
9		AMB.	"	"	"	"	"	
10		AMB.	"	"	"	"	"	
11		250	10 FT. LB.	10 FT. LB.	"	"	"	
12		250	"	"	"	"	"	
13		250	"	"	"	"	"	
14		250	"	"	"	"	"	
15		250	"	"	"	"	"	
16		250	"	"	"	"	"	
17		250	"	"	"	"	"	
18		250	"	"	"	"	"	
19		250	"	"	"	"	"	
20		250	"	"	"	"	"	
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEALN₂ PURGE PRESS. _____ PAGE 2 of 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL BREAK-AWAY TORQUE CW ROTATION	BALL BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		500	12 FT.LB.	12 FT.LB.	NONE	280 IN.LB.	AMB.	
2		500	"	"	"	"	"	
3		500	"	"	"	"	"	
4		500	"	"	"	"	"	
5		500	"	"	"	"	"	
6		500	"	"	"	"	"	
7		500	"	"	"	"	"	
8		500	"	"	"	"	"	
9		500	"	"	"	"	"	
10		500	"	"	"	"	"	
11		750	12.5 FT.LB.	13 FT.LB.	"	"	"	
12		750	"	"	"	"	"	
13		750	"	"	"	"	"	
14		750	"	"	"	"	"	
15		750	"	"	"	"	"	
16		750	"	"	"	"	"	
17		750	"	"	"	"	"	
18		750	"	"	"	"	"	
19		750	"	"	"	"	"	
20		750	"	"	"	"	"	
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNA

TECHNICIANS

W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEAL

E2 PURGE PRESS.

PAGE 3 of 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL BREAK-AWAY TORQUE CW ROTATION	BALL BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		1000	15 FT.LB	17 FT.LB	NONE	280 IN.LB	AMB.	
2		1000	"	"	"	"	"	
3		1000	"	"	"	"	"	
4		1000	"	"	"	"	"	
5		1000	"	"	"	"	"	
6		1000	"	"	"	"	"	
7		1000	"	"	"	"	"	
8		1000	"	"	"	"	"	
9		1000	"	"	"	"	"	
10		1000	"	"	"	"	"	
11		1250	17.5 FT.LB	18 FT.LB	"	"	"	
12		1250	"	"	"	"	"	
13		1250	"	"	"	"	"	
14		1250	"	"	"	"	"	
15		1250	"	"	"	"	"	
16		1250	"	"	"	"	"	
17		1250	"	"	"	"	"	
18		1250	"	"	"	"	"	
19		1250	"	"	"	"	"	
20		1250	"	"	"	"	"	
21								

DATE 6-4-62
 TIME DAY
 SUPERVISOR W. MENNONNA

TECHNICIANS W. RAILA
G. MEIER

TEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEAL
 N₂ PURGE PRESS. PAGE 4 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL BREAK-AWAY TORQUE CW ROTATION	BALL BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		1300	17.5 FT.LB	18 FT.LB	NONE	280 IN.LB	AMB.	
2		1300	"	"	"	"	"	
3		1300	"	"	"	"	"	
4		1300	"	"	"	"	"	
5		1300	"	"	"	"	"	
6		1300	"	"	"	"	"	
7		1300	"	"	"	"	"	
8		1300	"	"	"	"	"	
9		1300	"	"	"	"	"	
10		1300	"	"	"	"	"	
11		1350	18 FT.LB	18 FT.LB	"	"	"	
12		1350	"	"	"	"	"	
13		1350	"	"	"	"	"	
14		1350	"	"	"	"	"	
15		1350	"	"	"	"	"	
16		1350	"	"	"	"	"	
17		1350	"	"	"	"	"	
18		1350	"	"	"	"	"	
19		1350	"	"	"	"	"	
20		1350	"	"	"	"	"	
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. BAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEALN₂ PURGE PRESS. _____ PAGE 5 of 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL BREAK-AWAY TORQUE CW ROTATION	BALL BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		1400	20 FT. LB.	20 FT. LB.	NONE	280 IN. LB.	AMB.	
2		1400	"	"	"	"	"	
3		1400	"	"	"	"	"	
4		1400	"	"	"	"	"	
5		1400	"	"	"	"	"	
6		1400	"	"	"	"	"	
7		1400	"	"	"	"	"	
8		1400	"	"	"	"	"	
9		1400	"	"	"	"	"	
10		1400	"	"	"	"	"	
11		1450	"	"	"	"	"	
12		1450	"	"	"	"	"	
13		1450	"	"	"	"	"	
14		1450	"	"	"	"	"	
15		1450	"	"	"	"	"	
16		1450	"	"	"	"	"	
17		1450	"	"	"	"	"	
18		1450	"	"	"	"	"	
19		1450	"	"	"	"	"	
20		1450	"	"	"	"	"	
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
BALL STEM SEALN₂ PURGE PRESS.

PAGE 6 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	BALL LEAK AWAY TORQUE CW ROTATION	BALL LEAK AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON BALL STEM SEAL	TEST TEMP.	REMARKS
1		1500	21 FT. LB.	21 FT. LB.	NONE	280 IN. LB.	AMB.	
2		1500	"	"	"	"	"	
3		1500	"	"	"	"	"	
4		1500	"	"	"	"	"	
5		1500	"	"	"	"	"	
6		1500	"	"	"	"	"	
7		1500	"	"	"	"	"	
8		1500	"	"	"	"	"	
9		1500	"	"	"	"	"	
10		1500	"	"	"	"	"	
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEALN₂ PURGE PRESS. _____

PAGE 1 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	WEDGE BREAK-AWAY TORQUE CW ROTATION	WEDGE BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON WEDGE STEM SEAL	TEST TEMP.	REMARKS
1		AMB.	45 IN. LB.	40 IN. LB.	NONE	350 IN. LB.	AMB	A .004 INCH SHIM HAS BEEN PLACED BETWEEN THE
2		AMB.	42 "	"	"	"	"	GASKET BACKUP SLEEVE (54-105
3		AMB.	44 "	"	"	"	"	AND THE DYNAMIC GASKET (68-43
4		AMB.	45 "	45 IN. LB.	"	"	"	OF THIS STEM SEAL.
5		AMB.	44 "	40 "	"	"	"	DURING THIS TEST, THE WEDGE
6		AMB.	45 "	32 "	"	"	"	SHAFT WAS ROTATED 270° IN
7		AMB.	44 "	34 "	"	"	"	THE CLOCKWISE DIRECTION
8		AMB.	42 "	35 "	"	"	"	AND THEN 70° IN THE
9		AMB.	40 "	35 "	"	"	"	COUNTERCLOCKWISE DIRECTION.
10		AMB.	40 "	35 "	"	"	"	BALL & WEDGE NOT IN VALUE
11		250	60 "	47 "	"	"	"	DURING THIS TEST.
12		250	65 "	40 "	"	"	"	
13		250	65 "	44 "	"	"	"	
14		250	65 "	42 "	"	"	"	
15		250	65 "	50 "	"	"	"	
16		250	65 "	55 "	"	"	"	
17		250	65 "	55 "	"	"	"	
18		250	65 "	58 "	"	"	"	
19		250	70 "	60 "	"	"	"	
20		250	70 "	64 "	"	"	"	
21								

DATE 6-4-62
 SHIFT DAY
 SUPERVISOR W. MENNONNA

TECHNICIANS N. RAILA
G. MEIER

TEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEAL
N2 PURGE PRESS. PAGE 2 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	WEDGE BREAK-AWAY TORQUE CW ROTATION	WEDGE BREAK-AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON WEDGE STEM SEAL	TEST TEMP	REMARKS
1		500	7.5 FT. LB.	5 FT. LB.	NONE	350 IN. LB.	AMB.	
2		500	"	"	"	"	"	
3		500	"	"	"	"	"	
4		500	"	"	"	"	"	
5		500	"	"	"	"	"	
6		500	"	"	"	"	"	
7		500	"	"	"	"	"	
8		500	"	"	"	"	"	
9		500	"	"	"	"	"	
10		500	"	"	"	"	"	
11		750	9 FT. LB.	7 FT. LB.	"	"	"	
12		750	"	"	"	"	"	
13		750	"	"	"	"	"	
14		750	"	"	"	"	"	
15		750	"	"	"	"	"	
16		750	"	"	"	"	"	
17		750	"	"	"	"	"	
18		750	"	"	"	"	"	
19		750	"	"	"	"	"	
20		750	"	"	"	"	"	
21								

DATE 6-4-62
 SHIFT DAY
 SUPERVISOR W. MENNONNA

TECHNICIANS W. RAILA
G. MEIER

TEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEAL
 N2 PURGE PRESS. _____ PAGE 3 OF 3

Test No.	Time of Test	ADAPTEK VALVE PRESS.	WEDGE GEAR AWAY TORQUE CW ROTATION	WEDGE GEAR AWAY TORQUE CCW ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON WEDGE STEM SEAL	TEST TEMP.	REMARKS
1		1000	12 FT.LB.	7.5 FT.LB	NONE	350 IN.LB	AMB.	
2		1000	"	"	"	"	"	
3		1000	"	"	"	"	"	
4		1000	"	"	"	"	"	
5		1000	"	"	"	"	"	
6		1000	"	"	"	"	"	
7		1000	"	"	"	"	"	
8		1000	"	"	"	"	"	
9		1000	"	"	"	"	"	
10		1000	"	"	"	"	"	
11		1250	12.5	8 FT.LB	"	"	"	
12		1250	13	"	"	"	"	
13		1250	"	"	"	"	"	
14		1250	"	"	"	"	"	
15		1250	"	"	"	"	"	
16		1250	"	"	"	"	"	
17		1250	"	"	"	"	"	
18		1250	"	"	"	"	"	
19		1250	"	"	"	"	"	
20		1250	"	"	"	"	"	
21								

DATE 6-4-62SHIFT PAYSUPERVISOR W. MENNONNA

TECHNICIANS

W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEALN₂ PURGE PRESS. _____ PAGE 4 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	WEDGE BEARING AWAY TORQUE (CW ROTATION)	WEDGE BEARING AWAY TORQUE (CCW ROTATION)	VISIBLE STEM SEAL LEAKAGE	TORQUE ON WEDGE STEM SEAL	TEST TEMP.	REMARKS
1		1300	15 FT. LB.	10 FT. LB.	NONE	350 IN. LB.	AMB.	
2		1300	"	"	"	"	"	
3		1300	"	"	"	"	"	
4		1300	"	"	"	"	"	
5		1300	"	"	"	"	"	
6		1300	"	"	"	"	"	
7		1300	"	"	"	"	"	
8		1300	"	"	"	"	"	
9		1300	"	"	"	"	"	
10		1300	"	"	"	"	"	
11		1350	"	"	"	"	"	
12		1350	"	"	"	"	"	
13		1350	"	"	"	"	"	
14		1350	"	"	"	"	"	
15		1350	"	"	"	"	"	
16		1350	"	"	"	"	"	
17		1350	"	"	"	"	"	
18		1350	"	"	"	"	"	
19		1350	"	"	"	"	"	
20		1350	"	"	"	"	"	
21								

DATE 6-4-62
 SHIFT DAY
 SUPERVISOR H. MENNONNA

TECHNICIANS W. RAILA
CT. FIEBER

TEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEAL
N₂ PURGE PRESS. PAGE 5 of 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	WEDGE SEAL STUB TORQUE (NO ROTATION)	WEDGE SEAL TORQUE (NO ROTATION)	WEDGE SEAL TORQUE (WITH ROTATION)	TORQUE ON WEDGE STEM SEAL	TEST TEMP.	REMARKS
1		1400	16 FT.LB.	12 FT.LB.	NONE	350 IN.LB.	AMB.	
2		1400	"	"	"	"	"	
3		1400	"	"	"	"	"	
4		1400	"	"	"	"	"	
5		1400	"	"	"	"	"	
6		1400	"	"	"	"	"	
7		1400	"	"	"	"	"	
8		1400	"	"	"	"	"	
9		1400	"	"	"	"	"	
10		1400	"	"	"	"	"	
11		1450	17.5 FT.LB.	12.5 FT.LB.	"	"	"	
12		1450	"	"	"	"	"	
13		1450	"	"	"	"	"	
14		1450	"	"	"	"	"	
15		1450	"	"	"	"	"	
16		1450	"	"	"	"	"	
17		1450	"	"	"	"	"	
18		1450	"	"	"	"	"	
19		1450	"	"	"	"	"	
20		1450	"	"	"	"	"	
21								

DATE 6-4-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAG. MEIERTEST TITLE DYNAMIC LEAK TEST OF
WEDGE STEM SEALN₂ PURGE PRESS.

PAGE 6 OF 6

Test No.	Time of Test	ADAPTER VALVE PRESS.	WEDGE BREAK-AWAY TORQUE (CW) ROTATION	WEDGE BREAK-AWAY TORQUE (CCW) ROTATION	VISIBLE STEM SEAL LEAKAGE	TORQUE ON WEDGE STEM SEAL	TEST TEMP.	REMARKS
1		1500	18 FT. LB.	12.5 FT. LB.	NONE	350 IN. LB.	AMP.	
2		1500	"	"	"	"	"	
3		1500	"	"	"	"	"	
4		1500	"	"	"	"	"	
5		1500	"	"	"	"	"	
6		1500	"	"	"	"	"	
7		1500	"	"	"	"	"	
8		1500	"	"	"	"	"	
9		1500	"	"	"	"	"	
10		1500	"	"	"	"	"	
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								

DATE 6-11-62
 SHIFT DAY
 SUPERVISOR W. MENNONNA

TECHNICIANS W. RAILA
G. MEIER

TEST TITLE STATIC LEAK TEST OF
STEM SEALS AT HIGH TEMPERATURE
N2 PURGE PRESS.

Test No.	Time of Test	ADAPTER VALVE PRESS.	TORQUE ON WEDGE STEM SEAL	TORQUE ON BALL STEM SEAL	ADAPTER VALVE TEMP.	VISIBLE LEAKAGE BALL STEM SEAL	VISIBLE LEAKAGE WEDGE STEM SEAL	REMARKS
1		0 PSIG	350 IN. LB.	280 IN. LB.	180°F	NONE	NONE	A .004 INCH SHIM HAS BEEN PLACED BETWEEN THE GASKET
2		250	"	"	375	"	"	BACKUP SLEEVE (54-105) AND
3		500	"	"	410	"	"	THE DYNAMIC GASKET (68-432)
4		750	"	"	450	"	"	OF BOTH STEM SEALS
5		1000	"	"	475	"	"	
6		1250	"	"	490	"	"	
7		1300	"	"	490	"	"	
8		1400	"	"	500	"	"	
9		1500	"	"	520	"	"	
10		1400	"	"	490	"	"	
11		1300	"	"	480	"	"	
12		1250	"	"	480	"	"	
13		1000	"	"	450	"	"	
14		750	"	"	430	"	"	
15		500	"	"	400	"	"	
16		250	"	"	365	"	"	
17		0	"	"	200	"	"	
18								
19								
20								
21								

BALL-SEAL LEAK TESTSTest Equipment and Instrumentation

<u>Nomenclature</u>	<u>Manufacturer</u>	<u>Purpose</u>
1. 18 KW water heater	E. L. WIEGAND CO.	Supply heat to water in test circulating loop.
2. Pump	MILTON ROY CO.	Circulate water through test loop.
3. N ₂ cylinder	AIRCO	Maintain 1500 psig pressure in test loop.
4. Torque wrench	STURTEVANT	Apply required actuating torques to ball and wedge shafts.

Test Setup

Ambient-Temperature, Operating-Pressure Conditions. With the ball closed, leak testing of the adapter valve ball seal was conducted by filling the reactor side of the valve with water at ambient temperature. Nitrogen gas, the pressurizing medium, was piped into this side of the valve. Various tightening torques were applied to the wedge shaft to seat the ball-valve graphite-seat device. Any leakage past the ball seal was collected in the test chamber or the downstream side of the valve. The leakage was collected in a beaker graduated in cubic centimeters and when related to the elapsed time was considered the leakage rate.

Operating-Temperature, Operating-Pressure Conditions. Water from the high-temperature-water supply was circulated through the adapter valve until the operating pressure and temperature was reached. The ball valve was closed and the wedge lowered. Water circulation was continued through the reactor side of the valve and the machine or test chamber side of the valve was vented. A cylinder of nitrogen was piped to the top port of the test chamber, and a coil of copper tubing was connected to the bottom sort of the test chamber (see figure 24). The copper tubing also passed through cold water and had its

Figure 24. Hot Test Leakage Collection Method

outlet into either a container of desiccant or a beaker graduated in cubic centimeters. The test chamber was purged with nitrogen at 5 psig. Any leakage of the hot water (550°F) past the ball seal flashed into steam in the test chamber. The nitrogen purge directed the flow of steam out the bottom of the test chamber into the simulated copper-tubing heat exchanger. The condensed steam leakage was collected in either the desiccant container or the graduated beaker at the outlet of the coil.

Test Discussion and Test Procedure

Leakage Tests — Ambient Temperature

Initial test results obtained indicated that with a torque of 8 foot-pounds applied to the wedge shaft, leakage rates of 285 cc per hour at zero psig, and 90 cc per hour at 250 psig to 1500 psig can be expected; also, with a torque of 10 foot-pounds applied to the wedge shaft, leakage rates of 156 cc per hour at zero psig, and 60 cc per hour at 250 psig to 1500 psig can be expected. (See attached test data sheets.)

Leakage data was obtained with the wedge lowered to three different positions. These positions were realized by rotating the wedge shaft 180 degrees, 190 degrees and 200 degrees; the torque required to attain these positions was 15 foot-pounds, 20 foot-pounds, and 30 foot-pounds, respectively. The ball seal was leak tested under two different operating conditions, and the aforementioned wedge positions were used for each of the operating conditions. These operating conditions are explained as follows:

Ten leakage tests were conducted; seven with the ball closed and wedge lowered at ambient pressure. Leakage rates were obtained at various increments as the pressure was increased to 1500 psig. The remaining three tests were conducted by pressurizing the adapter valve to 1500 psig with the ball open, then closing the ball, lowering the wedge, and venting the downstream side of the valve. Leakage rates were then obtained as the upstream pressure was decreased to zero psig.

The leakage rates obtained during these ten tests were below the maximum acceptable leakage rate of 300 cc per hour. The average leakage rate was approximately 70 cc per hour. Varying the wedge force did not appear to vary the leakage rate. It is felt that at the wedge positions used during these tests, the wedge only assists in sealing the ball at the pressures below 200 psig. The hydraulic force of pressure above 200 psig is sufficient to seal the ball without the assistance of the wedge. (See attached test data sheets.)

During the original ball seal leakage tests conducted prior to wedge failure, leakage rates of 3 to 5 cc per hours were obtained. The wedge forces applied during these previous tests were much greater than those presently being used, i.e., 330-degree rotation of the wedge shaft or 100 foot-pounds. A wedge force of this magnitude apparently results in extremely effective sealing at the lower pressures without the assistance of hydraulic forces. The wedge force was reduced in order to avoid repeated damage to the wedge-to-wedge shaft connection.

Ball and Ball Key

The ball and ball-seat key (figure 25) were modified. This modification entailed pinning the ball to the ball-seat key to ensure their moving as a unit into the graphite seat as the wedge force is applied to the ball.

This was necessary since previous tests indicated that it was possible for the ball to improperly seated on the graphite seat if the ball-seat key became frozen in its keyway. If this were to occur the wedge force applied to the ball forces the ball to rotate upward on the ball seat key until the ball strikes the bottom of the ball shaft. Thus, the ball can become bound between the ball-seat key and at the top by the ball shaft preventing the ball from completing its axial movement into the graphite seat to produce an effective ball-seal action (see figure 26).

Ball Seal. With the ball pinned to the ball-seat key, the opening and

Figure 25. Ball and Key

BALL SHAFT KEYWAY WHEN
BALL KEY BINDS & WEDGE FORCE
ROTATES BALL UPWARD

IF WHEN THE BALL IS CLOSED AND THE WEDGE FORCE IS BEING APPLIED, THE BALL KEY BINDS IN ITS KEYWAY; THE AXIAL MOTION OF THE BOTTOM OF THE BALL TOWARD THE GRAPHITE SEAT WILL STOP. AS THE WEDGE FORCE INCREASES, THE BALL IS FORCED TO ROTATE IN THE BALL KEY UNTIL THE BOTTOM OF THE BALL SHAFT KEYWAY STRIKES THE BOTTOM OF THE BALL SHAFT.

THE BALL IS NOW BOUND BOTH TOP & BOTTOM AND ITS AXIAL MOVEMENT TOWARD THE GRAPHITE SEAT WILL STOP UNLESS THE WEDGE FORCE CAN "BREAK LOOSE" THE STUCK BALL KEY. IF THE BALL KEY REMAINS STUCK IN ITS KEYWAY, THE WEDGE FORCE CAUSES THE SHARP EDGE ON THE BOTTOM OF THE BALL SHAFT TO DIG INTO THE BALL SHAFT KEYWAY. UNDER THESE CONDITIONS THE BALL CANNOT BE SEATED PROPERLY IN THE GRAPHITE SEAT AND GROSS LEAKAGE OCCURS.

RECOMMENDED FIX

1. PIN BALL KEY TO BALL, TO BE CERTAIN THAT THEY WILL MOVE AS A UNIT
2. CUT RADIUS ON BOTTOM OF BALL SHAFT TO ELIMINATE POSSIBILITY OF SHARP EDGES DIGGING INTO BOTTOM OF BALL SHAFT KEYWAY
3. CUT RADIUS ON THE BOTTOM ENDS OF THE BALL KEY.

Figure 26. Analysis of Ball Positioning Problems

MAT.	SIZE OR PATT. NO.	DRAWN BY W.N.M.	DATE 6-27-62	
DESCR. ANALYSIS OF BALL POSITIONING PROBLEMS	CLASS	DIV.	NUMBER	

closing cycle of the ball valve was checked at ambient conditions. This check revealed that it was not possible to completely close the ball. The ball could only be rotated approximately 80 degrees toward the closed position. At this point the ball would not continue its rotation.

The adapter valve was then disassembled and the internals were inspected. A dimensional check of ball clearances (figure 27) in the valve housing was made. This check indicated that interference existed between the ball and the ball housing. One side of the ball as viewed from the graphite seat end of the valve was eccentric to the housing bore.

Previously, this situation did not exist since the ball was free to move laterally. With the ball pinned to the ball-seat key, the eccentric relationship prevented the ball from completing its closing cycle.

This binding was eliminated by elongating the hole in the key (figure 28) thus permitting the lateral motion of the ball during a sealing operation.

Ball-Seal Leak Tests

Leakage tests were repeated in order to check the operation of the ball seal with the ball pinned to ball-seat key. The tests were conducted at ambient-temperature, high-pressure conditions. Four leakage tests were conducted; two with the ball closed and wedge lowered at ambient pressure. Leakage rates were obtained as increased to 1500 psig. The remaining two tests were conducted by pressurizing the adapter valve to 1500 psig with the ball open, then closing the ball, lowering the wedge, and venting the downstream side of the valve. Leakage rates were then obtained as the upstream pressure was decreased to zero psig.

The leakage rates obtained during those four tests were well below the maximum acceptable leakage rate of 300 cc per hour. The average leakage rate was approximately 65 cc per hour at 1500 psig.

Figure 27. Dimensional Check of Ball Housing Interference

135

MAT.	SIZE OR PATT. NO.	DRAWN BY W. N. M.	DATE 7-18-62	
CHECK: DIMENSIONAL CHECK OF BALL BALL HOUSING INTERFERENCE		CLASS 89 DIV. 58 NUMBER 1630	MODEL REV.

Figure 28. Ball Seat Key — Reworked to Permit Lateral Ball Motion

MAT.	SIZE OR PATT. NO.	DRAWN BY	DATE
DESIGN: BALL SEAT KEY - REWORKED TO PERMIT LATERAL MOTION OF BALL	CLASS	DIV.	NUMBER	MODEL	REV.
	89	58	1681		

Ball-Stem Seal Failure

During these later ball-seal leak tests, the ball-stem seal leaked objectionably. The adapter valve was disassembled in order to remove and inspect the ball-stem seal. It was found that the sealing lip of the dynamic gasket was cracked and had become separated from the remainder of the dynamic gasket assembly (figures 29 and 30).

The seal was sent to the metallurgical lab for further inspection (figure 31) to determine the type of failure, i. e., fatigue or overstress.

A possible cause of this failure may be attributed to the ball shaft moving vertically 0.133 inch in the valve housing. When the adapter valve is pressurized, the ball shaft "popped up" when a pressure of 800 to 900 psig was reached. This rapid upward movement of the ball shaft may have flexed the sealing lip of the dynamic gasket and causing this failure.

In order to continue testing of the adapter valve, a jury-rig seal for the ball shaft was installed in the adapter valve. This seal consists of high-temperature-asbestos valve-stem packing, and a gland nut.

High-Temperature Testing of Adapter Valve-Ball Seal. With the ball stem sealed with high-temperature-asbestos valve-stem packing, high-temperature testing of the adapter valve was started. With the ball open, water was circulated through the valve. The temperature of the water was increased at a rate not exceeding 20°F per minute, and the adapter valve heater elements were utilized to maintain a temperature difference no greater than 50°F between the internal and external surfaces of the valve.

At a pressure of 800 psig and a temperature of 425°F, the wedge-stem seal failed (figure 32). The valve was allowed to cool and then disassembled. The wedge-stem seal was inspected and found to be cracked around the sealing lip of the dynamic gasket in a manner similar to the ball-stem seal failure. A jury-rig seal for the wedge stem was made from high-temperature-asbestos valve-stem packing, and high-temperature testing of the adapter valve was continued.

BALL STEM SEAL

Figure 29. Ball Stem Seal after Test Failure

MAT.		SIZE OR PATT. NO.		DRAWN BY <i>W. H. M.</i>		DATE <i>7-16-62</i>		TRADE MARK	
DESCR. <i>BALL STEM SEAL - AFTER TEST FAILURE</i>		CLASS <i>89</i>	DIV. <i>58</i>	NUMBER <i>1682</i>		MODEL	REV.

Figure 30. Damaged Seal

Figure 31. Metallurgical Analysis of Seal Damage

Figure 32. Cracked Stem Seal

With the ball open, water was circulated through the valve until the water temperature was 580°F at a pressure of 1500 psig.

The ball was then closed. The torque required to close the ball varied from 20 to 30 foot-pounds. The wedge was then lowered. It was found that the wedge could not be lowered to the desired position (190-degree rotation of the wedge shaft) until the downstream side of the ball was vented.

Before venting of the downstream side of the ball, a torque of 70 foot-pounds would not move the wedge further than a 160-degree rotation of the wedge shaft. With the downstream side of the valve vented the wedge was easily lowered to the same wedge position used during the ambient temperature tests (190 degrees) by a torque of 10 foot-pounds.

It was then decided to lower the wedge until the same torque applied during the ambient temperature tests was reached (25 foot-pounds). This torque was reached after a 240-degree rotation of the wedge shaft.

A one-hour leakage test was then conducted. At the conclusion of this test, the up and downstream pressure was equalized, the wedge raised and the ball opened. The torque required to raise the wedge was 5 foot-pounds and the torque required to open the ball was 25 foot-pounds.

A second one-hour leak test was then conducted. The ball was closed by a varying torque of 15 to 25 foot-pounds, the downstream side of the ball was vented, and the wedge was lowered to 240-degree rotation of the wedge shaft by a torque of 25 foot-pounds.

The average leakage rate for the two tests conducted was 125 cc per hour. (See attached test data sheets.)

A test was also conducted to determine the torque required to open the ball valve at high temperature with a 50 psi pressure differential across the ball.

With the ball open, water was circulated through the valve until the water temperature was 520°F at a pressure of 800 psig. The ball was then closed and the wedge lowered by a 160-degree rotation of the wedge shaft. At this point the wedge would move further down until the downstream side

of the valve is vented. The torques required to close the ball was 60, 40, 70 and 60 foot-pounds respectively for the four test cycles conducted.

The downstream side of the valve was then vented to 750 psig to provide a 50 psi differential across the ball. The wedge was raised by a torque of 20 foot-pounds and the ball was opened. A torque of 70 to 75 foot-pounds was required to "breakaway" the ball, the torque then dropped to 40 foot-pounds as the opening cycle was completed. This was accomplished successfully three times. During the fourth cycle the ball was opened enough to equalize the pressure across the ball by a torque of 70 foot-pounds. As the ball was rotated to its completely-open position, the ball seized after a rotation of 45 degrees (half-open). A torque of 90 foot-pounds would not move the ball past this point.

The valve was allowed to cool with the wedge withdrawn and the ball in the half-open position. It was found that the ball and ball housing were scored, and the graphite seat badly scarred (see figures 33, 34 and 35). Further effort to pinpoint the problem area is outlined below.

The ball and ball housing were repaired by polishing the high spots caused by the galling at high temperature. Measurements of the ball and ball housing were taken both at ambient and high temperature. (See figure 36.)

The ball and ball shaft were placed in an oven and heated to 600°F. Measurements were taken to determine expansion (see figure 36). The ball housing was heated to 580°F using the adapter valve heater elements. A temperature difference no greater than 50°F was maintained between the internal and external surfaces of the valve.

The measurements, taken at high temperature, indicate that there is a minimum clearance of 0.005 inch between the ball and the ball housing.

The adapter valve was reassembled in order to conduct a ball cycling test at high temperature. The clamp ring was not installed in the valve to eliminate a possible cause of galling of the ball and housing.

With the ball open, water was circulated through the valve until a pressure of 1200 psig and a temperature of 480°F was reached.

Figure 33. Ball Seat Damage

Figure 34. Valve Housing Galling

Figure 35. Galling on Ball

BALL

AMBIENT TEMPERATURE

A- 6.002
B- 6.002
C- 6.002
D- .750
E- .747

HIGH TEMPERATURE - 600°F

A- 6.028
B- 6.028
C- 6.028
D- .753
E- .750

AMBIENT TEMP.

A- 6.014
B- 6.021
C- 6.020
D- 6.015

HIGH TEMP - 580°F

A- 6.038
B- 6.050
C- 6.048
D- 6.040

BALL HOUSING

Figure 36. Ball and Ball Housing Expansion

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MAT. CANDU	SIZE OR PATT. NO.	DRAWN BY W.N.M.	DATE 7-25-62
DESCR. DETERMINATION OF BALL & BALL HOUSING EXPANSION AT 580°F TEMPERATURE	GLASS	DIV.	NUMBER	
				REV.

The test was unsuccessful as the ball seized in the valve housing during the first cycle. The torque required to close the ball was 50 foot-pounds. The ball seized during the opening cycle. A torque of 70 foot-pounds was required to breakaway the ball with zero pressure differential across the ball. This torque remained the same through approximately a 10-degree travel of the ball toward the open position. At this point the torque increased to 85 foot-pounds and the ball would not move any further toward the open position. After the valve was allowed to cool to 200°F the ball was easily rotated, however a slight binding was evident and caused the torque to vary from 15 to 20 foot-pounds. (See attached test data sheets.)

The adapter valve was disassembled and inspected. It was found that the ball and the ball housing were again scored due to galling.

In view of the repeated seizures between the ball and housing of the adapter valve, modification was necessary. This consisted of increasing the clearances in the affected area (see figures 37, 38 and 39). The high spots on the ball, caused by the galling action, were polished and the required machine work on the ID of the valve housing was completed.

A ball-cycling test at high temperature was conducted to determine if relieving the ID of the ball housing eliminated the galling condition between the ball and ball housing. The test was conducted without the clamp ring installed in the valve. The test was performed at a pressure of 1525 psi and a temperature of 560°F. The maximum torque required to rotate the ball under these conditions was 12 foot-pounds. No galling occurred.

The graphite seat was removed from the valve and its sealing surface was faced off to remove the scratches. A total of 0.025 inch was removed radially from the graphite seat. The adapter valve was reassembled and setup for further ball-seal-leak tests. To compensate for the 0.025 inch removed from the graphite seat, a shim 0.036-inch thick was placed behind the wedge backup ring. The standard test procedure was used during this test.

Figure 7. Adapter Valve Housing Modification

Figure 38. Ball Housing ID (Bottom)

Figure 39. Relieved Ball Housing ID (Top)

Forty-foot-pounds torque was required to close the ball at 1500 psi and 510°F. This torque was felt to be high and it appeared that the ball was binding in the valve. The leakage test was conducted for three hours with the following leakage rates determined:

1st hour	—	450 cc/hr
2nd hour	—	280 cc/hr
3rd hour	—	150 cc/hr

The adapter valve was then disassembled and inspected. It was found that the ball had become scratched and in turn had scratched the graphite seat. This accounts for the abnormally high leakage rate obtained. The ball housing was not galled. It appeared that the ball was damaged by the clamp ring. A piece of the chrome plating from the clamp ring had chipped away and caused scarring of the ball.

At this time, adapter valve testing, to obtain the required baseline and secondary data, was considered completed. Modifications, indicated by test results, are to be made to the valve before re-initiation of testing. Further cyclic testing of the valve will be accomplished during the system test of the refueling machine head assembly.

Test Data

DATE 6-22-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALL
SEAL LEAK TESTN₂ PURGE PRESS.

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1	5 MIN.	0	156	10 FT. LB.	170°	.094	AMB.	TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS - 7 FT. LB.
2		250	60	"	"	"	"	
3		500	60	"	"	"	"	
4		750	60	"	"	"	"	
5		1000	70	"	"	"	"	
6		1250	66	"	"	"	"	
7		1500	60	"	"	"	"	
8		1250	60	"	"	"	"	
9		1000	62	"	"	"	"	
10		750	58	"	"	"	"	
11		500	50	"	"	"	"	
12		250	56	"	"	"	"	
13		0	160	"	"	"	"	WEDGE RAISED, BALL OPENED, BALL THEN CLOSED, WEDGE LOWERED TO SAME POSITION
14		250	62	"	"	"	"	
15		750	65	"	"	"	"	
16		1250	70	"	"	"	"	
17		1500	70	"	"	"	"	
18		1250	60	"	"	"	"	
19		750	60	"	"	"	"	
20		250	48	"	"	"	"	
21		0	150	"	"	"	"	

DATE 6-22-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. BAILETEST TITLE ADAPTER VALVE BALL
SEAL LEAK TESTN₂ PURGE PRESS. _____

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		0	282	8 FT. LBS	150°	.083 IN.	AMB.	TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS - 7 FT. L ₂
2		250	90	"	"	"	"	
3		500	90	"	"	"	"	
4		750	90	"	"	"	"	
5		1000	90	"	"	"	"	
6		1250	90	"	"	"	"	
7		1500	90	"	"	"	"	
8		1250	84	"	"	"	"	
9		1000	84	"	"	"	"	
10		750	78	"	"	"	"	
11		500	78	"	"	"	"	
12		250	66	"	"	"	"	
13		0	290	"	"	"	"	WEDGE RAISED, BALL OPENED, BALL THEN CLOSED, AND WEDGE LOWERED TO SAME POSITION
14		250	90	"	"	"	"	
15		750	95	"	"	"	"	
16		1250	90	"	"	"	"	
17		1500	90	"	"	"	"	
18		1250	80	"	"	"	"	
19		750	76	"	"	"	"	
20		250	70	"	"	"	"	
21		0	260	"	"	"	"	

DATE 6-25-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALLSEAL LEAK TESTN₂ PURGE PRESS. _____

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		0	48	28 FT.LB.	200°	.112 IN	AMB	TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS - 12 FT.LB.
2	"	250	64	"	"	"	"	
3		500	74	"	"	"	"	
4		750	78	"	"	"	"	
5		1000	78	"	"	"	"	
6		1250	78	"	"	"	"	
7		1500	78	"	"	"	"	PRESS. RELIEVED.
8		0	52	"	"	"	"	WEDGE RAISED, BALL OPENED THEN BALL CLOSED, AND WEDGE
9		250	66	"	"	"	"	LOWERED TO SAME POSITION. TORQUE TO CLOSE BALL - 12 FT.LB.
10		500	72	"	"	"	"	
11		750	78	"	"	"	"	
12		1000	78	"	"	"	"	
13		1250	78	"	"	"	"	
14		1500	78	"	"	"	"	
15								
16								
17								
18								
19								
20								
21								

DATE 6-25-62TECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALLSHIFT DAYSEAL LEAK TESTSUPERVISOR W. MENNONNAN2 PURGE PRESS.

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		0	56	18 FT.LB.	190°	.106 IN.	AMB.	TORQUE REQ'D TO CLOSE BALL AT AMBIENT CONDITIONS - 12 FT.LB.
2		250	66	"	"	"	"	
3		500	78	"	"	"	"	
4		750	78	"	"	"	"	
5		1000	78	"	"	"	"	
6		1250	78	"	"	"	"	
7		1500	78	"	"	"	"	PRESS. RELIEVED
8		0	48	"	"	"	"	WEDGE RAISED, BALL OPENED THEN BALL CLOSED, AND WEDGE LOWERED TO SAME POSITION.
9		250	64	"	"	"	"	TORQUE TO CLOSE BALL - 12 FT.LB.
10		500	76	"	"	"	"	
11		750	78	"	"	"	"	
12		1000	78	"	"	"	"	
13		1250	78	"	"	"	"	
14		1500	78	"	"	"	"	
15								
16								
17								
18								
19								
20								
21								

DATE 6-26-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALL
SEAL LEAK TEST.N₂ PURGE PRESS. _____

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR.	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		1500	44	30 FT. LB	200°	.112 IN	AMB.	BALL CLOSED WITH VALVE AT 1500 PSI WEDGE THEN LOWERED.
2		1250	38	"	"	"	"	TORQUE REQ'D TO CLOSE BALL AT 1500 PSI - OPSI ΔP = 36 FT. LB.
3		1000	36	"	"	"	"	
4		750	36	"	"	"	"	
5		500	36	"	"	"	"	
6		250	24	"	"	"	"	
7		0	5	"	"	"	"	
8		1500	45	20 FT. LB	190°	.106 IN.	"	BALL CLOSED WITH VALVE AT 1500 PSI, WEDGE THEN LOWERED.
9		1250	35	"	"	"	"	TORQUE REQ'D TO CLOSE BALL AT 1500 PSI - OPSI ΔP = 30 FT. LB.
10		1000	35	"	"	"	"	
11		750	35	"	"	"	"	
12		500	35	"	"	"	"	
13		250	20	"	"	"	"	
14		0	6	"	"	"	"	BALL CLOSED WITH VALVE AT 1500 PSI WEDGE THEN LOWERED.
15		1500	40	15 FT. LB	180°	.100 IN	"	TORQUE REQ'D TO CLOSE BALL AT 1500 PSI - OPSI ΔP = 30 FT. LB.
16		1250	35	"	"	"	"	
17		1000	35	"	"	"	"	
18		750	35	"	"	"	"	
19		500	35	"	"	"	"	
20		250	22	"	"	"	"	
21		0	6	"	"	"	"	

DATE 6-27-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. KAILATEST TITLE ADAPTER VALVE BALLSEAL LEAK TESTN₂ PURGE PRESS. _____

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR.	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		0	42	15 FT.LB	180°	.100"	AMB.	TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS = 12 FT.LBS
2		250	54	"	"	"		
3		500	72	"	"	"		
4		750	72	"	"	"		
5		1000	72	"	"	"		
6		1250	72	"	"	"		
7		1500	72	"	"	"		PRESS. RELIEVED
8		0	46	20 FT.LB	190°	.106"		WEDGE RAISED, BALL OPENED AND THEN CLOSED, WEDGE LOWERED
9		250	78	"	"	"		TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS. = 12 FT. LBS
10		500	90	"	"	"		
11		750	90	"	"	"		
12		1000	90	"	"	"		
13		1250	90	"	"	"		
14		1500	84	"	"	"		PRESS. RELIEVED
15		0	40	30 FT.LB	200°	.112"		WEDGE RAISED, BALL OPENED AND THEN CLOSED, WEDGE LOWERED
16		250	54	"	"	"		TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS. = 12 FT. LBS
17		500	66	"	"	"		
18		750	72	"	"	"		
19		1000	78	"	"	"		
20		1250	72	"	"	"		
21		1500	72	"	"	"		

DATE 7-11-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALL
SEAL LEAK TEST.N₂ PURGE PRESS.

TESTS CONDUCTED WITH BALL PINNED TO BALL KEY

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR.	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DIS. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		1500	42	24 FT. LB.	190°	.106 IN.	AMB	BALL CLOSED WITH VALVE AT 15-450 PSI. WEDGE THEN LOWERED.
2		1250	35	"	"	"	"	TORQUE REQ'D. TO CLOSE BALL AT 1500 PSI - 0 PSI ΔP = 28 FT/LBS
3		1000	33	"	"	"	"	
4		750	30	"	"	"	"	
5		500	26	"	"	"	"	
6		250	15	"	"	"	"	
7		0	4	"	"	"	"	
8								BALL OPENED - WEDGE RAISED
9		1500	56	24 FT. LB.	"	"	"	BALL CLOSED WITH VALVE AT 1500 PSI. WEDGE THEN LOWERED
10		1250	50	"	"	"	"	TORQUE REQ'D TO CLOSE BALL AT 1500 PSI - 0 PSI ΔP = 28 FT/LBS
11		1000	45	"	"	"	"	
12		750	37	"	"	"	"	
13		500	31	"	"	"	"	
14		250	21	"	"	"	"	
15		0	6	"	"	"	"	
16								
17								
18								
19								
20								
21								

DATE 7-10-62
 SHIFT DAY
 SUPERVISOR W. MENNONNA

TECHNICIANS W. RAILA

TEST TITLE ADAPTER VALVE BALL
SEAL LEAK TEST
N₂ PURGE PRESS.

TESTS CONDUCTED WITH BALL PINNED TO BALL VALVE

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE CC/HR	TORQUE ON WEDGE SHAFT	ROTATION OF WEDGE SHAFT	VERT. DISP. OF WEDGE SHAFT	TEST TEMP.	REMARKS
1		0	30	25 FT. LB	190°	.106 IN.	AMB.	TORQUE REQ'D. TO CLOSE BALL AT AMBIENT CONDITIONS - 10 FT. LB.
2		250	56	"	"	"	"	
3		500	66	"	"	"	"	
4		750	72	"	"	"	"	
5		1000	76	"	"	"	"	
6		1250	76	"	"	"	"	
7		1500	76	"	"	"	"	
8								PRESSURE RELIEVED. WEDGE RAISED, BALL OPENED - THEN BALL CLOSED, AND WEDGE LOWERED TO SAME POSITION.
9		0	32	25 FT. LB.	190°	.106 IN.	AMB.	TORQUE TO CLOSE BALL - 10 FT. LB.
10		250	60	"	"	"	"	
11		500	70	"	"	"	"	
12		750	72	"	"	"	"	
13		1000	76	"	"	"	"	
14		1250	78	"	"	"	"	
15		1500	78	"	"	"	"	
16								
17								
18								
19								
20								
21								

DATE 7-19-62
SHIFT DAY
SUPERVISOR W. MENNONNA

TECHNICIANS W. EAILA

TEST TITLE ADAPTER VALVE BALL SEAL
LEAK TEST - OPERATING CONDITIONS
N₂ PURGE PRESS.

Test No.	Time of Test	TEST PRESS.	BALL SEAL LEAKAGE	BALL SEAL LEAKAGE CC/HR	H ₂ O TEMP.	WEDGE SHAFT ROTATED	TORQUE ON WEDGE SHAFT	ADAPTER VALVE HEATERS	REMARKS
1	TEST NO. 1 30 MIN	1500 PSI	80 cc	160	580°F	240°	25 FT. LB.	ON-30 MIN. OFF-	1. GIMBAL HTR. NOT OPERATING. 2. ADAPTER VALVE BROUGHT TO 1500 PSI - 580° WITH BALL OPEN. BALL THEN CLOSED AND WEDGE LOWERED. TORQUE REQUIRED TO CLOSE BALL = 30 FT. LB.
2	30 MIN	1450 PSI	70 cc	140	580°F	240°	25 FT. LB.	ON-30 MIN. OFF-	WEDGE COULD NOT BE LOWERED UNTIL DOWNSTREAM SIDE OF VALVE WAS VENTED. A TORQUE OF 70 FT. LB. WOULD NOT LOWER WEDGE - NOT WISHING TO FORCE WEDGE DOWN THE DOWNSTREAM SIDE OF VALVE WAS THEN VENTED.
3									
4									
5									
6									
7									
8	TEST NO. 2 30 MIN	1400 PSI	60 cc	120	580°F	240°	25 FT. LB.	ON-30 MIN OFF	1. UP & DOWNSTREAM PRESS. EQUALIZED. 2. BALL OPENED - WEDGE RAISED.
9	30 MIN.	1300 PSI	40 cc	80	580°F	240°	25 FT. LB.	ON-30 MIN OFF-	BALL THEN CLOSED AND WEDGE LOWERED TO SAME POSITION. TORQUE TO OPEN BALL - 25 FT. LB. TORQUE TO RAISE WEDGE - 5 FT. LB.
10									TORQUE TO CLOSE BALL - 20 FT. LB.
TOTALS	2 Hour	1425 AVG.	62 cc AVG.	125 AVG.	580°F	240°	25 FT. LB.	ON CONTINUOUSLY	
11									
12									
13									BOTH BALL AND WEDGE
14									STEMS SEALED WITH
15									ASBESTOS VALVE STEM
16									PACKING DURING THIS TEST.
17									
18									
19									
20									
21									

DATE 7-19-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE ADAPTER VALVE BALL SEALLEAK TEST - VALVE SURFACE TEMPS.N2 PURGE PRESS.

THERMOCOUPLE NOS.

Test No.	Time of Test	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	REMARKS
1	#1	525	555	600	500	560	540	500	520	230	505	190	570	TEMP. READINGS TAKEN EVERY 10 MIN
2	#1	530	565	580	505	600	560	520	540	220	520	220	590	
3	#1	535	570	590	530	560	520	545	530	220	510	230	580	#12 READS LOW BECAUSE IT WAS IN THE PATH OF A STEAM LEAK FROM THE FUEL STOP FLANGE.
4	#1	535	575	580	510	580	530	540	525	200	510	230	580	
5	#1	540	575	605	510	570	525	560	520	230	500	230	590	
6	#1	535	570	590	510	570	530	555	525	240	500	230	580	
7	#2	540	580	610	515	595	550	570	535	260	490	230	595	HEATERS ON CONTINUOUSLY DURING THIS TEST.
8	#2	540	580	615	520	590	550	570	525	270	480	235	590	
9	#2	540	580	610	520	590	550	570	525	270	490	240	590	GIMBAL HEATERS NOT OPERATING DURING THIS TEST.
10	#2	545	580	610	510	580	530	565	525	265	480	230	590	
11	#2	545	580	605	515	580	540	570	530	270	490	235	590	
12	#2	545	580	605	515	580	530	570	530	275	490	240	590	
13														
14														
15														
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21														

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE ____ OF ____

FOR CALCULATION SERIAL NO.

JOB ORDER NO.

CONTRACT NO.

#8 INTERNAL
H₂O INLET

THERMOCOUPLE LOCATIONS

CLASS	DIV.	NUMBER	MODEL
-------	------	--------	-------

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PREPARED BY

CHECKED BY

DATE

DATE

AMERICAN MACHINE
&
FOUNDRY COMPANY

CALCULATION SHEET

PAGE _____ OF _____

FOR CALCULATION SERIAL NO. _____

JOB ORDER NO. _____

CONTRACT NO. _____

THERMOCOUPLE LOCATIONS

164

PREPARED BY

CHECKED BY

DATE

DATE

MODEL

NUMBER

DIV.

CLASS

DATE 7-20-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILATEST TITLE DETERMINATION OF TORQUE
REQD TO OPEN BALL WITH ΔP ACROSS BALL
N₂ PURGE PRESS.

Test No.	Time of Test	ZERO ΔP ACROSS BALL		ΔP ACROSS BALL		TORQUE TO OPEN BALL	TORQUE TO RAISE WEDGE	H ₂ O TEMP.	REMARKS
		TORQUE TO CLOSE BALL	TORQUE TO SEAT WEDGE	UPSTREAM PRESS.	DOWN-STREAM PRESS.				
1		60 FT.LB	*80 FT.LB	8.00	750	70 FT.LB	20 FT.LB	520°	ALL TORQUE INPUTS APPLIED DIRECTLY TO BALL AND WEDGE STEMS.
2		40 FT.LB	*70 FT.LB	775	725	75 FT.LB	" "	520°	
3		70 FT.LB	*70 FT.LB	775	725	75 FT.LB	" "	520°	BOTH BALL AND WEDGE STEMS SEALED WITH ASBESTOS VALVE STEM PACKING
4		60 FT.LB	*80 FT.LB	775	725	SEE NOTE	" "	520°	
5									BALL STEM TARE = 25 FT.LB
6									WEDGE STEM TARE = 20 FT.LB
7									
8									* WEDGE SHAFT ROTATED 160° - AT THIS POINT THE WEDGE WILL NOT MOVE FURTHER DOWN UNTIL DOWNSTREAM SIDE OF VALVE IS VENTED
9									
10									
11									
12									NOTE - WITH A 50 LB ΔP ACROSS THE BALL A TORQUE
13									OF 70 FT.LB. WAS REQUIRED TO OPEN BALL ENOUGH TO
14									EQUALIZE THE PRESS. ACROSS THE BALL. AS THE BALL WAS
15									ROTATED TOWARD ITS COMPLETELY OPEN POSITION THE BALL
16									BECAME STUCK AFTER A ROTATION OF 45° TOWARD
17									THE OPEN POSITION. INCREASING THE TORQUE TO 90 FT.LB. STILL
18									WOULD NOT MOVE THE BALL. IT WAS POSSIBLE TO RETURN
19									THE BALL TO THE CLOSED POSITION BUT FURTHER
20									EFFORTS TO OPEN THE BALL MET WITH THE SAME RESULT
21									THIS DID NOT OCCUR DURING THE FIRST THREE TEST RUNS.

DATE 7-27-62SHIFT DAYSUPERVISOR W. MENNONNA

TECHNICIANS _____

TEST TITLE HIGH TEMPERATURE
BALL CYCLING TESTN₂ PURGE PRESS. _____

Test No.	Time of Test	PRESS.	WATER TEMP.	TORQUE TO CLOSE BALL	TORQUE TO OPEN BALL				REMARKS
1		1200	480°F	* 50 FT. LB.	* * 70 FT. LB.				
2									1. TEST CONDUCTED WITHOUT THE CLAMP RING (5014-4) INSTALLED IN THE VALVE.
3		VALVE	ALLOWED	TO COOL					
4		400	200°F	15-20	15-20				2. WATER WAS CIRCULATED THROUGH THE ADAPTER VALVE WITH THE BALL OPEN THE BOTTOM OF THE BALL WAS PINNED TO THE BALL SEAT KEY.
5									
6									
7									
8									
9									
10									
11									* BREAKAWAY TORQUE ON BALL WAS 20 FT. LB. - TORQUE INCREASED UNTIL A TORQUE OF 50 FT. LB. WAS REACHED AT A 90° ROTATION OF THE BALL (CLOSED POSITION)
12									
13									
14									* * A TORQUE OF 70 FT. LBS. WAS REQUIRED TO BREAKAWAY FROM THE TORQUE REMAINED CONSTANT THROUGH APPROX. A 10° TURN OF THE BALL, THE TORQUE THEN INCREASED TO 85 FT. LB. AND BALL WOULD NOT MOVE PAST THIS POINT.
15									
16									
17									
18									
19									AFTER THE VALVE WAS ALLOWED TO COOL TO 200°F THE BALL WAS EASILY ROTATED - HOWEVER A SLIGHT BINDING WAS DETECTED AND CAUSED THE TORQUE TO VARY FROM 15 TO 20 FT. LBS.
20									
21									

DATE 8-3-62SHIFT DAYSUPERVISOR W. MENNONNATECHNICIANS W. RAILAA. PANISHTEST TITLE BALL CYCLING TEST AT
HIGH TEMPERATUREN₂ PURGE PRESS.

Test No.	Time of Test	TEST PRESS.	H ₂ O TEMP.	TORQUE TO CLOSE BALL	TORQUE TO OPEN BALL				REMARKS
1		1525	560°F	8 FT. LB.	10 FT. LB.				1. TEST CONDUCTED WITHOUT THE CLAMP RING (5014-4) INSTALLED IN THE VALVE.
2		"	"	8	10				
3		"	"	8	10				2. TORQUE INPUTS APPLIED DIRECTLY TO THE TOP OF THE BALL SHAFT.
4		"	"	8	10				
5		"	"	8	10				3. AT AMBIENT CONDITIONS BALL STEM TARE WAS:
6		"	"	8	10				OPEN - 8 FT. LB. CLOSE - 8 FT. LB.
7		"	"	9	11				
8		"	"	10	12				4. TEST CONDUCTED AFTER VALVE HOUSING REWORKED
9		"	"	10	12				PER 89-58-1686.
10		"	"	10	12				
11		"	"	10	12				
12		"	"	10	12				
13		"	"	10	12				
14		"	"	10	12				
15		"	"	10	12				
16		"	"	10	12				
17		"	"	10	12				
18		"	"	10	12				
19		"	"	10	12				
20		"	"	10	12				
21									

APPENDIX A

ALTERNATE ADAPTER VALVE

An alternate adapter valve concept (see Figure 46, AMF-388-TR-2) was considered essential to the On-Power Refueling Machine in that operation of the entire machine depended on an operable adapter valve. Studies were initiated in Task I, tests of feasible alternates were performed in Task II, and Task III activity resulted in design concept layouts of alternate components and an alternate adapter valve assembly.

The engineering and design targets were a shorter over-all length, a reduced number of seal-requiring penetrations, reduced weight, improved reliability, and a reduction in potential maintenance.

DESIGN FEATURES

A sliding-disc assembly was the basic component which positively shut off reactor fluid and separated and controlled the fuel bundles as they pass through the valve body.

These two operations are performed as separate and distinct motions from a single actuator shaft. An electrical actuator rotates the disc approximately 90 degrees to perform these actions. A spring, incorporated in the design, preloaded the disc sufficiently to provide the initial sealing action. Final sealing is effected through valve positioning causing line pressure to act on the disc, thereby increasing sealing pressure.

Part of the alternate valve is the remote clamping mechanism and the spherical joint. These devices permit the valve to couple or uncouple from the reactor process tube within anticipated misalignment conditions.

Seals were also required at the spherical joint, actuator stem, and at the reactor-process-tube mating face.

Homing sensors are also provided to control the X- and Y-axis carriage fine-position drive systems. Electrical heaters, placed around the valve periphery, provide heat to assure thermal matching of the process tube and valve housing as required.

The design concept is described in detail in the Task I Completion Report, AMF-388-TR-2. The results of testing the feasibility of a typical sliding-disc valve in support of this concept is contained in the Task II Component Feasibility Test Report, AMF-388-TR-1, pages 7-1 through 7-22.